REPORT

OF THE

Agricultural Research Institute and College, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

1911-12

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1913

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TABLE OF CONTENTS.

PAGE.

I. Report of the Director, Agricultural Research Institute and College, Pusa—

1. Charge 1
2. Staff and work of the Institute . . . 1
3. Agriculture 3
4. Chemistry 4
5. Botany 6
6. Mycology 8
7. Entomology 9
8. Pathological Entomology 10
9. Bacteriology 11
10. Training 12
11. Buildings and Works 13
12. Library 13
13. Publications 13
14. General Health of the Station . . . 14
15. Accounts 15
16. Visitors 15

II. Report of the Imperial Agriculturist—

1. Charge and Establishment 17
2. Training 18
3. Character of the Season 18
4. Cropping 18
5. Cattle-breeding Herd 18
6. Sheep 18
7. Pastures 19
8. Clearing and Levelling 19
9. Fodder 19
10. Implements and Machinery 19
11. Experiments 19
12. Poultry 20
13. Programme of work for 1912-13 . . . 20

III. Report of the Imperial Agricultural Chemist—

1. Charge and Establishment 23
2. Meteorology 23

PAGE.

3. Drainage Data 23
4. The Water Requirements of Crops . . . 24
5. Soils—*Usar* 24
6. Saltpetre 25
7. Sugar 25
8. Date Palm Sugar Industry 26
9. De-Cobbing Maize Plants 27
10. Experimental Error in Sampling Sugarcane . 27
11. Sugar Beet Roots 28
12. Milk 28
13. Education 29
14. Programme of work for 1912-13 . . . 29
15. Publications 30

IV. Report of the Imperial Economic Botanist—
Part I.—Teaching, Training and Staff . . 31
Part II.—Wheat Investigations . . . 31
Part III.—Other investigations 43
(1) Tobacco 43
(2) Gram 45
(3) Fibres 46
(4) Pollination 46
Part IV.—The Tirhut Agricultural Exhibition . 46
Part V.—The Development of the Fruit Industry of Baluchistan . . . 48
Part VI.—Programme of work for 1912-13 and Publications 51

V. Report of the Imperial Mycologist—
1. Charge and Establishment 54
2. Training 54
3. Aid to Provincial Departments . . . 54
4. Plant Disease Investigations 55
5. Systematic Work 62
6. Miscellaneous 63
7. Programme of work for 1912-13 . . . 63
8. Publications 64

VI. Report of the Imperial Entomologist—
1. Charge and Establishment 65
2. Visitors 66

PAGE.

3. Training 66
4. Provincial Work 66
5. Correspondence 68
6. Research 69
7. Insecticides 69
8. Sericulture 69
9. Lac Culture 70
10. Apiculture 70
11. Demonstration 71
12. Insect Survey 71
13. Programme of work for 1912-13 . . . 71
14. Publications 72

VII. Report of the Imperial Pathological Entomologist—

1. Report 74
2. Programme of work for 1912-13 . . . 76

VIII. Report of the Imperial Agricultural Bacteriologist—

1. Charge and Establishment 78
2. Tours 78
3. Soil Bacteriology 78
4. Plant Pathology 81
5. Programme of work for 1912-13 . . . 82
6. Publications 83

IX. Report of the Imperial Cotton Specialist—

1. General 84
2. Cultivation of Cotton in Provinces:—
   (*a*) The Central Provinces and Berar . . 85
   (*b*) The Punjab 89
   (*c*) The United Provinces 99
   (*d*) Madras 103
   (*e*) Mysore State 107
   (*f*) The North-West Frontier Province . 107
   (*g*) Experiments with Bhuri Cotton on the Khetri estate in Rajputana . . . 108
   (*h*) Bombay 109
3. Valuations 113
4. Programme of work for 1912-13 . . . 113

Report of the Agricultural Research Institute and College, Pusa,

(*Including the Report of the Imperial Cotton Specialist*)

1911-12.

REPORT OF THE DIRECTOR.

(B. Coventry, C.I.E.)

1. *Charge.*—Dr. E. J. Butler held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, in addition to his own duties of Imperial Mycologist till the end of March 1912. At the end of the financial year 1911-12, the two posts of Inspector General of Agriculture in India and of Director, Agricultural Research Institute, Pusa, were amalgamated into one of Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Since that date, I have held charge of the combined offices. Mr. A. C. Dobbs, who was formerly Assistant Inspector General of Agriculture in India, held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1912, when he proceeded on six months' combined leave.

2. *Staff and work of the Institute.*—The work of the Institute as carried on in the seven scientific sections into

which it has been organised has been detailed in the reports of the several sections which are embodied in this report.

The Chemical Section was in the charge of Dr. J. Walter Leather. Mr. H. E. Annett, the Supernumerary Agricultural Chemist, was, till November 6th, 1911, on deputation to the United Provinces Department of Agriculture, to act as Principal of the Cawnpore Agricultural College. He left Pusa again on 9th May 1912 to act as Agricultural Chemist to the Government of the Punjab.

Mr. A. Howard was in charge of the Botanical Section. From July to September 1911 and during May and June 1912, he was at Quetta in connection with the development of the Fruit Industry in Baluchistan. The services of Mr. E. Holmes-Smith, the Supernumerary Botanist, were terminated on 7th October 1911.

The Mycological Section was in charge of Dr. E. J. Butler, throughout the year except from 17th June to 6th July 1912, when he was on privilege leave: during this period Mr. F. J. F. Shaw, the Supernumerary Mycologist, officiated for him.

Mr. H. Maxwell-Lefroy, the Imperial Entomologist, was on long leave throughout the year. Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, held charge of the section until April 19th, 1912, when he proceeded to Coimbatore to take up the new appointment as Entomologist to the Government of Madras. Mr. A. J. Grove joined his appointment as Supernumerary Entomologist on October 27th, 1911, and since Mr. Fletcher's transfer to Madras, has carried on the work of the Entomological Section.

The designation of the Second Imperial Entomologist has been altered to that of Imperial Pathological Entomologist, and Mr. Howlett held charge of the section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson.

The Agricultural Section continued under the charge of Mr. A. C. Dobbs, until April 27th, 1912, when he proceeded on leave. Mr. S. Milligan, Deputy Director of

Agriculture, Punjab, has been transferred to this Institute to take up the post of the Imperial Agriculturist. He joined the appointment on May 8th, 1912. Mr. H. Southern, Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last to take up the appointment vacated by Mr. Milligan. Mr. G. D. Mehta was appointed Supernumerary Agriculturist on 4th June 1911. Until 30th May 1912 he was working at Poona under the Government of Bombay and from that date he has been posted to the Central Provinces for training. Messrs. W. S. McGowan and Thomas Gilbert were appointed Supernumerary Agriculturists on 23rd February 1912. The former is posted to Bihar and Orissa to act as Professor of Agriculture at the Agricultural College, Sabour, and the latter is working under the Government of Bombay.

3. *Agriculture.*—The rainfall during the year amounted to 56·30 inches. The monsoon arrived early and gave a plentiful rainfall. Floods, however, damaged the *kharif* crops, while late rain retarded the sowing of the *rabi* crop. The permanent manurial and rotation experiments started in 1908 with the object of studying the maintenance of the fertility of the soil have been continued. It is too soon yet to expect definite results from these experiments. The improvement of the sugar-cane crop on the ridge and furrow system combined with intertillage has been taken up and promises to be an important advance upon the methods in vogue in North India. It is proposed to apply the same system in a modified form to some of the *kharif* crops such as maize, which have already shown great improvement from liberal spacing and intertillage as well as from the free drainage induced by ridging. Among the use of chemical manures the application of crude sulphate of soda to paddy gave an increase of 17 maunds of grain per acre. This is a preliminary result requiring confirmation. The application of green manuring with *san* hemp combined with the moderate application of superphosphate at the time of sowing the *san* continues to give good results and is

the chief means by which the fertility on the farm is maintained against heavy and continuous cropping.

A new and important feature in the experimental work on the farm is a series of plots in which the biological factor connected with the use of green manuring as well as other bacteriological problems will be studied by the Imperial Agricultural Bacteriologist in conjunction with the Imperial Agriculturist. Too much stress cannot be laid on this work, which is now generally recognised as affording a most promising field for research into the principles underlying the fertility of soils.

4. *Chemistry.*—The work on the availability of plant food in soils and that of the moisture requirements of crops to which reference has been made in previous reports is being continued. The examination of water after passing through certain depths of soil continues to be carried out. It has been observed that not only is there less nitrate in the drainage water from the cropped soil than from fallow land, but the deficiency could not be accounted for merely by assimilation by the crop. Dr. Leather, therefore, deduces that either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The investigations in *Usar* soil which have been going on for some years have so far not led to any very useful nor definite results.

In the last Annual Report mention was made of the investigation into the date-palm sugar-industry which was carried on by Mr. Annett, the Supernumerary Agricultural Chemist. This has been continued during the past year and has led to an accumulation of very valuable information on the subject, which is now in the press and will soon appear as one of the Memoirs of this Department. Besides recording the history of this industry Mr. Annett gives a good description of the cultivation and tapping of the palm and the manufacture of the raw and refined sugar. He found that the juice contains 8 to 10 per cent. of sucrose, associated with practically no glucose. This fact indicates that it is an exceedingly good materials for the production

of white sugar direct from the juice. Owing, however, to imperfect methods of collection, 1 to 2 per cent. glucose is formed during the night and this amount is again greatly increased by the subsequent primitive treatment, thereby occasioning very great loss in white sugar. In an account of this work Mr. Annett draws attention to the great improvements which have been introduced into the corresponding American Industry of Maple Sugar, though in this case the juice which forms the raw material contains only 3 per cent. of sucrose. If improved methods could be applied to the Indian Palm Sugar Industry, there is no doubt not only that it would add to the profits of the sugar maker, but that the white sugar produced would assist to some extent in checking the encroachment of foreign white sugar into this country. The importance of this problem can be gauged by the fact that the production of sugar from the palm tree in India amounts to some 480,000 tons.

Some important work has been carried on in the Chemical Section during the year in the endeavour to establish a reliable method of milk tests for Indian cattle. When testing cows' milk in India two sources of error have to be guarded against; (1) if the periods between milking are not equal, the composition of the milk will be influenced, and (2) the calf will take an indefinite amount of milk if this is not controlled. In order to eliminate these sources of error the cows are milked exactly at intervals of 12 hours, and the calf is allowed to take the whole of the milk from only two teats on one side of the udder, the other side being milked by hand and the calf being made to change the side every 24 hours. In this way the difficulties described were overcome. While great regularity was as a rule obtained in the composition of the milk, yet it was possible to observe characteristic differences. The chief of these was that the percentage of butter fat in the morning was greater than that in the evening milk by ·5 to 1·5 per cent. and there was no exception to this rule. No systematic difference was found, in the composition of the milk, between the different sides of the udder.

5. *Botany.*—The wheat work continues to absorb a very large portion of the time of this section. The extended trials of the past year go to confirm previous results, and give prominence to the important fact that high yielding power and good grain qualities can be combined in the same plant. Stress is again laid upon the need of good cultivation and the repeated favourable results obtained therefrom entirely warrant this. As so much of the wheat exported from India is grown under irrigation it was important to ascertain by experiment whether wheats of good quality and high yielding power could be obtained in the canal districts. This has been done. Extended trials of the Pusa wheats have been made at Cawnpore and yields of over 2,200 lbs. per acre and in one case of 2,500 lbs. were obtained with a single watering. That is to say it was obtained with one-third of the water usually used by the cultivators in the neighbourhood. As regards quality they were found to possess baking qualities equal, if not superior, to the wheats grown at Pusa without irrigation. Mr. Howard, in this year's report, gives detailed accounts of the results of the extensive trials which were made of his wheats, in the wheat tracts of India, to which reference is invited. Owing to the success of these experiments, a great demand has arisen in various parts of India for the new wheats. Arrangements have, therefore, been made, to grow during the coming season, a large stock of seed, which it is expected will meet all demands.

Experiments on the influence of the environment on the quality are being continued and extended, with the object of finding out how far high quality in grain is possible in different wheat tracts. If wheat of good quality such as has been grown at Pusa and Cawnpore could be grown in any of the wheat tracts of India, the fact would be of very great importance, as the Indian wheats of commerce are mostly of poor quality. So far wheats grown on such varied soils as the alluvium and the black cotton soil did not lose their milling and baking qualities. Mr. Howard likewise maintains that in any particular wheat the condi-

tions which produce the highest yield are those which produce the best quality.

Not by any means the least important aspect of the work on wheat is that of breeding. Rust resistance, high yield, and strong straw in order to carry a heavy weight of grain are points to which attention is being particularly devoted.

Amongst other important investigations are those connected with the tobacco plant. The object of these experiments is to endeavour to establish a suitable plant for the manufacture of cigarettes, which are fast supplanting the *hooka*. Three types Nos. 28, 29 and 32 were grown and were cured by a slight modification of the country method. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 was very well reported on and was valued at from Rs. 12 to Rs. 14 per maund which is a considerable advance on local prices. Arrangements are now being made to repeat these results if possible amongst the cultivators.

Gram is another important crop to which Mr. Howard has been giving his attention, and he has shown by preliminary trials that there exists a very large margin on which to work out improvements both in yield and quality. Thus as the result of samples sent to Messrs. Ralli Brothers one variety was valued at Rs. 4-8-0 per cwt. and another at Rs. 5-8-0 per cwt. as compared with the price of Rs. 4-2-0 of the ordinary export varieties. The yields too were extraordinarily high being over 30 maunds per acre.

The work on the botanical characteristics of fibre plants and the study of the methods of pollination in the various Indian crops are being continued.

The development of the Fruit Industry of Baluchistan is a piece of work which is now assuming important proportions, and a fruit experiment station has been established about two miles from Quetta. It will take some little time before the model fruit garden comes into bearing, but in the mean time an old fruit garden has been taken over and improvements are being applied to it. The questions of packing and transport are being thoroughly gone into and

the results of the past season's experiments give promise that the cheap, quick and safe transit of first quality fruit to any part of India will soon be an accomplished fact.

6. *Mycology.*—An investigation is in progress into the disease of paddy known as *ufra* which is causing great damage in the Noakhali and other districts of Eastern Bengal. At first it was not known whether it was caused by a fungus, an insect, or some other cause. A conjoint entomological and mycological investigation resulted in the exclusion of insects as the direct cause and suspicions have been thrown upon an eel-worm so small that it is barely visible by the naked eye. It is estimated that in the Begumganj Thana alone, in the Noakhali district, some 200,000 maunds of grain was destroyed in 1910, and last year about half the crop was destroyed. The disease also occurs in Comilla, Chandpur, and the neighbourhood of Dacca. Dr. Butler, the Imperial Mycologist, is devoting special attention to this disease.

Mr. F. J. F. Shaw, the Supernumerary Mycologist, has devoted a great deal of attention to the rot induced by the soil-dwelling parasite known as *Rhizoctonia.* Its existence is very widespread, and it attacks crops such as potatoes, jute, groundnut, cow-pea and cotton, though so far cereal crops fortunately appear to be immune to this disease. Good tillage and a suitable rotation of crops are thought to be the best ways of preventing its ravages.

Further work has been done on wheat rust, which is a serious disease in this country in certain years. Thus there was last year a severe attack in the Central Provinces, the first for a number of years. The damage was caused by the variety known as " Orange " rust (*Puccinia triticina*) and much of the loss in 1912 must be attributed to it. In breeding rust resistant wheats therefore, for the Central Provinces, Dr. Butler is of opinion that this variety of rust should be taken into account, as well as the " black " rust (*Puccinia graminis*) which does much damage in normal years. The variety known as " yellow " rust (*Puccinia glumarum*), does not appear to be of importance. Diseases due to *Phytophthora*, Sugarcane diseases, among others one

resembling *Sereh* and occurring on the Jorhat Farm in Assam, the Betelnut Palm disease, the Indigo disease and other diseases, connected with tea, cotton and coffee, as well as diseases of forest trees, have engaged the attention of this section during the year.

A very large amount of systematic work has also been done, and some hundreds of specimens, of plant parasites for the most part, have been added to the named herbarium collection. Two parts of the list of Indian fungi were prepared in collaboration with Messrs. H. and P. Sydow of Berlin, and published—containing some 300 species of Indian fungi, of which more than a hundred were new to science.

7. *Entomology.*—In Madras a campaign has been carried out against the Deccan Grass-hopper. The method known as "bagging" was adopted, more or less successfully, and the ploughing of infested lands was carried out. Besides this a leaflet was issued in English, and in the vernacular, giving a description of the methods to be adopted against this pest. Experiments against White Ants were continued in the Central Provinces. The application of kerosene oil was found most effective in dealing with the mound-building variety of termites. The collection and despatch to the Punjab of parasites of the cotton boll-worm formed an important aspect of the work of the section, as dependence is placed upon this parasite in order to keep in check the ravages of the insect. This method of controlling this pest is being adopted in Egypt, and parasites have recently been sent to that country for this purpose. A leaflet has been issued in the vernacular explaining how this remedy should be used. In the United Provinces measures have been adopted against the Rice Grass-hopper which has become a serious pest of sugar-cane in that province. The method of storing seed potatoes in sand as a protection against the Potato moth was successfully demonstrated to cultivators in Bengal. At Mokameh a campaign was organised against *Agrotis ypsilon*, a caterpillar which has been destroying the crops in that region. The picking off

of the first brood of caterpillars and the setting up of the Andres-Maire traps reduced the damage to such an extent that, out of a total area of 20,000, only 2,000 bighas were affected.

Sericulture has continued to claim a large amount of the attention of the section. Experiments are in hand for crossing the Indian multivoltine variety of mulberry silk-worm with the univoltine races from Europe, with the object of producing a superior silk-producing multivoltine hybrid. If this work is successful it will go a very long way towards placing the Indian silk industry, now in a precarious position, on a more stable footing. Eri-silk culture, Lac-culture and Api-culture continue to occupy the attention of the section.

8. *Pathological Entomology.*—This section, which was formerly styled the Second Entomological Section, now confines its attention to entomological work connected with the diseases of men and animals, and its name has in consequence been changed. Its relation with medical work has now become much closer, and, through the good services of the Medical Research Fund, the addition of three posts has been made to the subordinate staff. These extra men will be occupied exclusively with Medical Entomology, while there will be two men available for Veterinary and general work.

Special attention has been paid to the genus *Stegomyia* and allied forms of the mosquito owing to the possibility of importation of Yellow Fever into India from the Panama Canal, and a course of instruction has been given to medical officers belonging to the "Stegomyia Survey." Investigations are in progress on the influence of temperature, range of flight, food, breeding places, etc., and on the natural enemies of mosquito-larvæ.

The other subjects that are receiving attention are the breeding places and habits of *Phlebotomus*, the life history of the Crab-louse, the parasites of *Tabanus albimedius*, *Monophlebus stebbingi*, and the life history of *Celyphidæ*. The East Indian Railway school at Jharipani was success-

fully rid of a plague of bugs by the application of hydrocyanic acid.

9. *Bacteriology.*—The principal work of this section during the past year has been the study of the factors which determine the biological activity of Indian soils, and the devising of methods by which this activity may be ascertained and measured. The usual plan of estimating bacteria by " plating " has been abandoned in favour of the measurement of their resulting physiological activities. Thus, for example, it has been ascertained that the biological activity of a soil is in direct proportion to the rate of formation of carbon dioxide, and that conditions unfavourable to the former will also adversely influence the latter. It is possible in this way to determine the optimum conditions of moisture content, the effect of the addition of various manures, organic and mineral, and the influence which tillage will have upon any particular soil. The biolysis of green manures, root residues, and organic manures, in so far as they form the supply of available nitrogen, has been undertaken.

It has been found that important differences exist in the biological changes that take place in Indian and European soils. These differences appear to be due mainly to the relatively higher temperatures and consequent greater bacterial activity of Indian soils. At temperatures between 15° C. and 18° C. the formation of ammonia is in proportion to the nitrification which follows it, but when temperatures rise from 25° C. to 30° C. ammonification may proceed with such rapidity that nitrification is interfered with, and even inhibited altogether, by an excess of ammonia. If, therefore, large quantities of organic matter are applied to a soil, much nitrogen may be lost in the form of ammonia—which shows the necessity that exists for selecting the most suitable time of year for applying organic manures. It has also been ascertained that where intense bacterial action is taking place in a soil, nitrates present will be reduced, without the occurrence of anærobic conditions, lending support to the belief that the nitrate is

utilised as a source of nitrogen by the bacteria themselves. These considerations tend to show what great care should be exercised in a tropical country like India in the treatment of the soil, if its supplies of plant food are not to be dissipated or wasted, and it also confirms the opinion which is now ripening into positive fact, that the study of the biologic factor in soils is of supreme importance, and that very important results are to be expected from it.

A special enquiry, also, is proceeding into the conditions determining the formation of bacterio-toxins in soils, and into their effect on crops.

10. *Training.*—The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle and Poultry management, Sericulture and Lac cultivation. Of the two post-graduate students in Agricultural Chemistry, admitted in the previous year, one continued his course, but the training of the second was terminated, as he was considered not likely to prove himself an efficient assistant. The two students in Entomology, mentioned in the previous year's report, left during the year; one after completing his course, and the other before its completion, as he was recalled to his province. The Assistant Director of Agriculture, Punjab, who was deputed to this Institute for a two years' course in general agriculture, completed his training on 21st August 1911, and returned to his province.

During the year under report four new students were admitted for training in Agricultural Chemistry. Of these, two are Government stipendiaries (one from Bengal and one from the Travancore State) and two are private students. A private student deputed by the Department of Agriculture, Travancore, was admitted, for training in general entomology. The Agricultural Department of Bihar and Orissa have deputed an Entomological and Mycological Collector for training in Mycology and Entomology. One advanced student from the Agricultural Department of the Central Provinces was given training,

in the Botanical Section, from October 1st, 1911, to the end of April 1912.

During the year under report, 33 students attended the short courses—two in 'Cattle management,' one in 'Poultry management,' seventeen in 'Sericulture' and thirteen in 'Lac cultivation.'

11. *Buildings and Works.*—During the year under report two small supplementary Laboratories were constructed, departmentally, for the use of the Imperial Agricultural Bacteriologist and the Imperial Pathological Entomologist, respectively. Residential quarters were also constructed for the use of the Superintendent of the Office of the Agricultural Adviser.

12. *Library.*—The Library is rapidly becoming overcrowded. Proposals for its extension have been submitted. During the year under report about 1,400 volumes have been added.

13. *Publications.*—The issue of the Journal, Memoirs and Bulletins was continued. The Department published during the year 14 Memoirs and 4 Bulletins, against 7 Memoirs and an equal number of Bulletins in the previous year. As noted in the last year's report, the Provincial Departments are supplying an increasing volume of contributions for these publications.

In consequence of the abolition of the Journal of Tropical Veterinary Science from 1st April 1912, it has been decided that articles of a popular character on veterinary subjects should be inserted in the Agricultural Journal of India. Contributions unsuited for the Journal, by reason of their being too technical, will be published in the form of Veterinary Memoirs which are now among the Scientific Memoirs issued by the Agricultural Department. They will be issued from time to time as matter becomes available. The editing committee has been strengthened by the appointment of the Imperial Bacteriologist, Muktesar, as a co-editor. The grant for the agricultural periodicals and Journal, which was curtailed

during the previous year to Rs. 23,000 remained unaltered during the year under report, but the Government of India have added Rs. 2,000 for Veterinary Memoirs, so that the total grant for publications now amounts to Rs. 25,000. As the work of the Department expands the matter for publication likewise increases, and the present grant will not be sufficient. It will be necessary to increase the funds for this work.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 9,081 new cases, of which 8,913 were treated in the out-patients department, and 168 admitted as indoor patients, an increase of 1,424 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers and cholera in the surrounding villages.

Two hundred and ninety-nine cases amongst European officers and families were attended to, an increase of a hundred and fifty-three over last year's total.

The daily average number of patients treated was 7·59 indoor and 53·6 outdoor against 7·87 and 49·05 respectively during the previous twelve months.

Five deaths occurred in hospital—

Two from cholera.
One from malarial cachexia.
One from dysentery.
One from phthisis and pneumonia.

Nine cases of cholera occurred among the families of the Indian staff during the months of May and June 1912 with two deaths. Immediate and successful measures were taken to prevent the disease spreading in Pusa, including the thorough cleansing and disinfection of all the wells in the Estate.

One hundred and twenty-one surgical operations were performed, of which twenty-five were major and ninety-six minor operations.

Quinine was issued prophylactically on the Estate, towards the close of the monsoon.

Twenty-four primary vaccinations and eight revaccinations were performed in the early part of the year.

15. *Accounts.*—The total expenditure during the financial year 1911-12 was Rs. 3,04,045, as under :—

	Rs.
Agricultural Research Institute, Pusa—	
Office of the Director	69,015
Chemical Section	41,012
Mycological Section	19,622
Entomological Section	37,345
Pathological Entomological Section .	24,188
Botanical Section	41,542
Bacteriological Section	22,108
Agricultural Section	49,213
TOTAL .	3,04,045

16. *Visitors.*—Visitors to Pusa between 1st July 1911 to 30th June 1912, numbered among others :—

The Hon'ble Mr. Syed Ali Imam, C.S.I., Bar.-at-Law, Member in charge of the Legislative Department, Government of India.

Mr. Abdul Aziz, Bar.-at-Law, Peshawar.

Mr. C. V. Piper of the United States Department of Agriculture, America.

The Hon'ble Sir R. W. Carlyle, K.C.S.I., C.I.E., I.C.S., Member in charge of the Department of Revenue and Agriculture, Government of India.

The Hon'ble Mr. W. H. Clark, C.S.I., C.M.G., Member in charge of the Department of Commerce and Industry, Government of India.

Mr. R. Nagamine, Director of the Government Stock Farm in Formosa.

Mr. T. Kawakami, Director of the Government Museum, Formosa.

Lieutenant-Colonel C. Norie, Dehra Dun.

Mr. D. Quinlan, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal.

The Hon'ble Surgeon-General Sir C. P. Lukis, M.D., F.R.C.S., K.C.S.I., Director General, Indian Medical Service.

The Hon'ble Mr. R. C. C. Carr, I.C.S., Officer on Special Duty in the Board of Revenue, Madras.

Mr. A. E. Andrews, Entomologist to the Indian Tea Association.

Dr. A. D. Imms, Forest Zoologist.

Dr. H. Morstatt, Entomologist at Amani, German East Africa.

Munshi Akhtar Mohammad Khan, Deputy Collector in the United Provinces.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. Milligan, M.A., B.Sc.)

1. *Charge and Establishment.*—The Pusa Farm and Experimental Station continued under the charge of Mr. Dobbs, Assistant Inspector General of Agriculture in India, till April 28th, 1912, when he proceeded on leave. I joined my appointment as Imperial Agriculturist on May 8th.

Mr. H. Southern, B.A., Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last, to take up a similar appointment there.

Mr. Ganpatlal Dayashanker Mehta, L.Ag., B.A., N.D.A., N.D.D., late of the Bombay Agricultural Department, was appointed Supernumerary Agriculturist on 4th June, 1911, and has been on deputation under the Bombay Government at Poona.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. He obtained three months' leave from July to October during which period Mr. L. S. Joseph officiated for him.

Messrs. Md. Ikramuddin and Md. Ziauddin Hyder held the appointments of Farm Overseers throughout the year. Mr. Ikramuddin arranged the camps of the Board of Agriculture and of the Tirhut Agricultural Show at Pusa, and his services in this connection were acknowledged by both bodies.

Mr. Nizamuddin Hyder of the staff of the Inspector General of Agriculture had charge of the poultry-breeding experiments until 26th October 1911, when he reverted to his original post on the staff of the Fibre Expert to the Government of Eastern Bengal and Assam. Mr. Ali Murtaza, Fieldman, was appointed in his place.

2. *Training.*—Mr. M. Fatehuddin, B.A., Assistant Director of Agriculture, Punjab, completed his two years' course of training in general agriculture on 21st August, 1911, and returned to the Punjab.

Three students attended the short courses on Cattle-breeding and Poultry management.

3. *Character of the Season.*—The rainfall during the year amounted to 56·30″. The monsoon arrived early and gave copious rainfall throughout its duration. Three severe floods damaged the kharif crops considerably and a late flood retarded the sowings of the rabi crop. The oat crop sustained some damage through late winter rains.

4. *Cropping.*—The following is a list of crops grown :— barley, oats, wheat, castor, bhindi, sugar-cane, jute, rice, maize, arhar (*Cajanus indicus*). Other crops grown on small plots for the Entomological Section included a number of millets and pulses.

5. *Cattle-breeding Herd.*—The numbers of the breeding herd are as follows :—

Cows 74, Bulls 5, Young stock 118

against „ 69, „ 3, „ „ 105 in 1911

Eleven cows, one bull and 19 young cattle have been sold during the year.

An outbreak of Foot and Mouth Disease in August 1911 caused the death of nine of the young stock. There was, however, no mortality in the milking herd from this cause. Three cases (all fatal) of black quarter occurred in June of this year. The Veterinary Overseer is to be congratulated on the prompt and successful measures undertaken to prevent an epidemic of this disease. The local Veterinary Department rendered valuable assistance in preventive inoculation.

6. *Sheep.*—The Gorakhpur sheep continue to do well. Dumbha rams are still used for crossing. The progeny will be used as a basis for the further improvement of wool production.

7. *Pastures.*—As indicated in last year's report a 4-acre plot was laid down to permanent pasture after a green manure.

8. *Clearing and Levelling.*—Roads have been constructed in the low-lying brick-field area and a portion of the waste land reclaimed.

9. *Fodder.*—The economic value of guinea grass as a fodder has been established and returns up to 350 maunds per acre obtained.

10. *Implements and Machinery.*—The wheat and oat crops were mostly cut by machines. The futility of a short cutting bar was demonstrated by the average daily work of two machines, *viz.*:—

A.	4½ ft. cut	. . .	5½ acres per day.
B.	3 „	. . .	3 „ „

The general cultivation has been much improved by the use of light ploughs of the Rajah and Punjab types which suit local conditions.

Spring toothed harrows have been found useful in preparing land for crops and maintaining summer fallows.

11. *Experiments.*—The following experiments are in progress and will be continued—

(*1*) The permanent manurial and rotation experiments started in 1908.

(*2*) The improvement of the sugar-cane crop by trenching, earthing up and intertillage.

(*3*) Experiments with regard to the sprouting of sugar-cane sets. A promising start was made last year by steeping the sets in water at 100° F.

(*4*) The application of crude sulphate of soda to paddy. An increase of 17 maunds of grain per acre on a 5-acre experiment was obtained last year. This preliminary result requires confirmation as information regarding the uniformity of the plots treated was not complete.

12. *Poultry.*—The following 5 out of 31 breeds imported and put under trial have been selected as suitable for the country and for crossing purposes :—

(1) Buff Orpington.
(2) White Wyandotte.
(3) Chittagong.
(4) Lakha Game.
(5) Mammoth Bronze Turkeys.

Owing to the rejection of unsuitable breeds, the general condition of the birds has shown a great improvement on previous years.

13. Programme of work for 1912-13.

In addition to the permanent experiments recorded above the following will be undertaken :—

General.—The organization of the estate work has been recently altered and the fieldmen now hold charge of independent sections. It is hoped that a more intimate acquaintance with the varying soil conditions will be made possible.

The large low-lying brick-field area will be further subdivided by roads. A good deal of levelling remains to be done before much detailed field experimenting can be undertaken, but this work will be pushed on as rapidly as possible.

Cropping.—A great improvement has been made in the general cultivation by the adoption of regular rotations. A special study of the maintenance of the fertility of the soil under the rotation and system of manuring adopted will be made. This system includes a dressing of superphosphate applied directly to a green manure. Quantitative estimates of the artificial manures necessary and the period of application will be made.

Field experiments have been started in collaboration with the Imperial Agricultural Bacteriologist to gain in-

formation regarding the decomposition of green manures under varying conditions of—

(*a*) Water content of the soil,
(*b*) Air content of the soil,
(*c*) Age of plant at time of burying,
(*d*) Depth of burying,

and as to the effect of such manures on the condition of the soil.

Cultivation.—Special investigations as to the value of intertillage by bullock implements in maize and sugar-cane will be undertaken. Correct spacings for maize both as a fodder and grain crop will be studied.

An improvement in the methods of working the heavier low-lying land appears to be necessary and improved implements will be given a trial.

Breeding Herd.—The present Montgomery herd is doing satisfactorily, although the milk yield is not as high as might be desired. Owing to the demand for milk from the subordinate staff and the want of budget provision for extensive purchases a rigid selection of the best milking cows has not been possible. This tends to keep down the average yields. Line breeding will be necessary as pedigree cattle of this breed are not obtainable in the country.

Sheep.—The young Gorakhpur Dumbha cross ewes will be used as a foundation for further improvements in wool production. It seems necessary to investigate what type of fleece is the most suitable for sheep in the plains of Northern India, whether a loose coat with a good length of staple or a close fine coat. It is also necessary to regularize and limit the lambing period, to cast the ewes at regular ages, and to employ a more rigid selection as regards wool.

Pastures.—A study of the agricultural characters of pasture grasses and legumes will be undertaken with a view to the sowing of mixtures instead of pure cultures of *dubh*. The effect of rolling, harrowing and topping pastures will

be noted. The rough river-side grazing areas will be systematically cut and grazed with the object of their ultimate improvement. The question of the cheapening of the present methods of laying out of land to pasture will be taken up.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. Walter Leather, Ph.D., F.I.C., F.C.S.)

1. *Charge and Establishment.*—This section was in the charge of myself during the whole year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned to duty at Pusa on 6th November 1911 from Cawnpore, where he had been acting as Principal of the Agricultural College. He left Pusa again on May 9th, 1912, to act as Agricultural Chemist, Punjab.

Mr. Bhailal Motibhai Amin has continued on deputation at the Sirseah Indigo Research Station. Babus Narain Lal Tewari and Narendra Nath Mitra, M.Sc. (All.), are the two new assistants, who have been appointed to fill vacancies which had occurred.

2. *Meteorology.*—In addition to the usual meteorological observations which are submitted to the Meteorological Department monthly, records are maintained of (*i*) pressure by means of a barograph, (*ii*) soil temperatures at depths of 1 in. down to 2 ft. from the land surface by means of maximum and minimum thermometers, and (*iii*) evaporation from a plain water surface.

3. *Drainage Data.*—The amount of water which drains annually from fallow land and from land bearing crops is determined at Pusa and at Cawnpore by means of gauges, descriptions of which have been published.* The water is analysed regularly in regard to certain constituents, such as nitrogen compounds and mineral matters. The records of the first few years have been published as a Memoir† of this Department. The chief deductions admissible from these records were detailed in my last annual report.

* Annual Report of Cawnpore Farm, 1905-06, page 23, and Memoir of the Department of Agriculture in India, Chemical Series, Vol. I, No. 5.

† Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2.

Among the observations made was that not only was there less nitrate in the drainage water from the cropped soil than from the fallow land, but that the deficiency could not be accounted for merely by assimilation by the crop. Either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The crops had been wheat and maize at Pusa. In order to test if a like result is obtainable when other crops are grown, the maize has been replaced by sunn hemp; and wheat is grown in rotation on one gauge only. In this manner it is hoped to ascertain whether there is a deficiency of nitrate in the drainage water from this system of cropping as there was from the wheat-maize.

Reference was also made in my last report to estimations of nitrate in fallow land throughout the season. These were continued last monsoon and cold weather and will be repeated during the coming cold weather.

4. *The Water Requirements of Crops.*—Work was continued on this subject during last cold weather, more especially with reference to the transpiration ratio of crops grown in the Cawnpore soil. This soil had not been employed previously in the pot-culture experiments at Pusa and also the field experiments at Cawnpore had been interfered with by bad seasons. The pot-cultures yielded ratios very similar to what had been obtained in other soils. The field plots yielded results which differed from those at Pusa chiefly in the fact that the soil moisture was drawn upon by the plant from a greater depth than was the case at Pusa.

5. *Soils. Usar.*—The nature of the work on *usar* soil in the United Provinces has been indicated in previous reports, and especially in my last year's report. The examination of the soils taken from alkali spots in the Muttra and Etah Districts left no doubt that these alkali spots are identical in character whether they occur under well or under canal irrigation. The experiments which have been in progress at Pusa on some soil which was taken originally

from good land closely contiguous to alkali land, and which were designed to demonstrate whether such soil would become *usar* if maintained in a water-logged state, have not so far yielded a definite answer. Both soils were examined after being under experiment for two years, and one was apparently still quite good; in respect of the other there was a doubt as to whether it had changed somewhat.

The whole series of tests were reported upon to the Director of Land Records and Agriculture and to the Chief Engineer, Irrigation Branch, United Provinces.

A series of samples of soil from Quetta were submitted to me for examination by the Irrigation Officer in Baluchistan, the question being whether irrigation was causing the lands to become saline. It was known from analyses made by me in 1909 how very saline the water of the Sheboo canal frequently is, and there is a natural suspicion that irrigation with it must lead to an accumulation of salts in the soil. The examination of the soils showed that in three cases out of four the irrigated land was less readily permeable to water than the unirrigated, and in two cases the irrigated land contained rather more salts. The difficulty in making a reliable deduction in questions such as this lies in the fact that the changes which may be going on are only slow and hence frequently difficult to detect.

6. *Saltpetre.*—Further experiments were made during the year on an improved method for refining crude saltpetre. The filter, which had worked very well at the Allahabad Exhibition, proved, when made of a considerably larger size, to be defective, and experiments are now being conducted with another class of filter which it is hoped will be more efficient. The refined saltpetre was sold in Calcutta without any difficulty at full market rates.

7. *Sugar.*—Work on sugar during the past year has included (*i*) an examination of the date sugar industry, (*ii*) testing the effect of removal of cobs from maize which results in an accumulation of sugar in the stem, (*iii*) estimating the error which is involved in sampling sugar-cane,

and (*iv*) an examination of sugar beet roots which were grown near Peshawar.

8. *The Date Palm Sugar Industry.*—As mentioned in my last annual report, an investigation of the date palm sugar industry was commenced at my suggestion by Mr. Annett during the cold weather of 1910-11. This was continued during the cold weather of 1911-12 and has resulted in an accumulation of some very valuable information on the subject. In addition to a review of its past history, Mr. Annett has been able, by spending some months in the Jessore District, to obtain an intimate knowledge of the present conditions of the industry, its agriculture, mode of cultivation, tapping, and manufacture of the raw and refined sugars. Also he conducted a long series of tests in camp in Jessore on the quantity and composition of the juice, the amount of decomposition and the means by which this might be prevented. Mr. Annett found that the fresh juice contains 8 to 10 per cent. of sucrose associated with practically no glucose, but that owing to imperfect methods of collection, 1 to 2 per cent. of glucose is formed during the night. There are also subsequently further losses of sugar during the boiling process, which is at present carried out in small earthen pots, and again during the native refining processes losses of sugar occur. In an account of this work, which is to be published, Mr. Annett refers to the great improvements which have been introduced into the corresponding American industry—the maple sugar manufacture—in which case it is to be noted that a juice containing only some 3 per cent. of sugar forms the "raw material." If one can afford to employ good appliances and perfected methods in that industry, it should certainly be possible to apply them to India's date sugar.

The reference to this investigation would be incomplete without an acknowledgment to Mr. E. G. McLeod of Kotechandpur, who rendered Mr. Annett very considerable assistance and provided him with detailed information of the profits and losses of his (Mr. McLeod's) factory.

9. *De-cobbing Maize Plants.*—Several Agricultural Journals* have contained notes on the effect of removing the cobs from maize plants prior to fertilisation by the pollen, this process being said to result in an accumulation of sugar in the stem. Experiments were made by Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, during last monsoon period in order to test the effect of the process and to ascertain whether it would prove itself a useful one. Analyses of the plants showed that an increase of sugar (sucrose) did occur; in one case the cane sugar rose from 2 per cent. to 9 per cent., the percentage referring to the weight of stem, but the process was not considered on the whole to be an economical one.

10. *Experimental Error in Sampling Sugar-cane.*—It will be readily appreciated that when a sample of cane is taken from a field which is supposed to represent the whole, an error is involved, and the examination of the sample will not show the average composition of the whole but will depart from the true value to a greater or less degree. It is also obvious that not only is a knowledge of the magnitude of this error of importance, but also that it is very desirable to know how to take a sample of sugar-cane in order to free the result of such errors as far as possible.

Some tests were made in 1910 and again this year with the sugar-cane crop which were designed to elucidate the subject, but it will be necessary to carry out a third series of tests during the coming season in order to arrive at definite conclusions. In illustration it may be mentioned that if a sample of 3 or 6 canes is taken from a field the "probable error" is about 1 per cent. to 2 per cent. in the sucrose determination. By taking more and more canes in the "sample" the error becomes naturally smaller, but even if one-fourth of the crop of a $\frac{1}{10}$-acre plot be crushed, an appreciable error still remains, and one-fourth of such a crop is a large quantity of cane. It is the size of the smallest necessary sample to be taken in order to secure an

* Agricultural Journal of the Union of South Africa, Vol. I, No. 4, p. 540. Agricultural News, Vol. X, No. 234, p. 115.

error less than a certain magnitude that we desire to estimate.

11. *Sugar Beet Roots.*—Some samples of sugar beets which had been grown near Peshawar by the Superintendent of Farms were examined and the result is of interest because one lot included beets of a high grade. The percentage of sucrose varied in this lot between 17 per cent. and 20 per cent. of sucrose in the juice, demonstrating that very good sugar beet could be grown in Northern India if desired.

12. *Milk.*—In co-operation with Mr. A. C. Dobbs a series of tests were made during the year on the quantity and composition of the milk of the Montgomery herd at Pusa which have led to some interesting results. The work will not be completed until next year, but the following will indicate its nature.

When testing cows' milk in India two sources of error must be guarded against : (*i*) if the periods between milking are not equal the composition of the milk will be influenced, and (*ii*) the calf takes an indefinite quantity of the milk unless this is specially controlled. In order to eliminate these sources of error the cows were milked at 12 hour intervals, and the calf allowed to take the whole of the milk from only one side of the udder, the other half being milked by hand. The cows were milked by hand for 24 hours on (say) the right hand side of the udder whilst the calf took the milk from the left hand side, and then during the succeeding 24 hours the left side would be hand-milked, whilst the calf took milk from the right side. Moreover the diurnal change from the right hand side to the left hand side was made in the morning for one month, and in the evening during the next month. During one period of two months the milk of the fore and hind quarters of the udder of three cows was separately examined.

By these means great regularity was obtained in the composition of the milk and several characteristic differences were observed. The most prominent was the difference between the percentage of fat in the morning and evening milk; the former always contained from ·5 to 1·5 per

cent. more than the latter; the difference was greater with some than with other cows, but no cow was an exception to the rule. No *systematic* difference was found in the composition of the milk of the one side of the udder and the other side, but a *systematic* difference was observed with two cows in the composition of the milk of the fore quarter udder and hind quarter respectively. This latter point was tested with only three cows, so that whether this is a common or an exceptional characteristic of the cows is not yet known. The percentage of fat in the milk of this herd has been about 4 to 5 per cent. in the morning and 3 to 4 per cent. in the evening, which is less than has been found for Sind and Gir cows at Poona.

Regarding the *yield* of milk this was found to be from 5 to 6 lbs. per day *obtained by hand*, to which must be added the like quantity taken by the calf, making 10 to 12 lbs. or say 5 to 6 seers daily which is also less than what the Sind and Gir cows yield.

13. *Education.*—There are at present five students in this section; three of these being Government stipendiary students, one each from Bengal, Bihar and Orissa and Travancore; and two private students. One of the students mentioned in my last report was considered not likely to prove himself an efficient assistant and he was consequently not permitted to complete his full course of study. One student of the Entomological Section took a special course of photography.

14. Programme of work for 1912-13.

1. The work on the availability of plant food in soils will be continued.

2. In the current work on the moisture requirements of crops, the effect of different proportions of moisture in various soils for various crops is being ascertained.

3. The investigation of the chemistry and manufacture of date palm sugar will be continued.

4. Experiments on possible improvements in the manufacture of saltpetre will be continued.

5. The experimental error in sampling sugar-cane is being ascertained.

6. The effect of certain factors, such as climatic changes, time of milking, etc., on the composition of cow's milk, is being investigated.

7. *Education.*—This requires no special comment and will be conducted according to the lines laid down.

16. Publications.

The following papers have been published :—

1. "*Records of Drainage in India.*"—Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2, January 1912.
2. "*Flow of Water and Air through Soils.*"—Journal of Agricultural Science, Vol. IV, Part 3.
3. *The effect of* (i) *alkali and* (ii) *impermeability in soils on plant growth.*—(VIII International Congress of Applied Chemistry.)
4. *Method for the determination of the rate of percolation of water through soils.*—(VIII International Congress of Applied Chemistry.)
5. *Report on Industrial and Agricultural Chemistry* for the Board of Scientific Advice (by Messrs. Leather, Hooper and Puran Singh).
6. *Date Palm Sugar.*—Memoir of the Department of Agriculture in India (*in the press*).

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(A. Howard, M.A., A.R.C.S., F.L.S.)

Part I.

Teaching, Training and Staff.

Charge.—I held charge of the section at Pusa during the period under review, namely, the year ending June 30th, 1912.

Students.—One advanced student from the Agricultural Department of the Central Provinces worked in the section from October 1st, 1911 to the end of April 1912. This student made considerable progress in spite of his want of familiarity with growing crops.

Staff.—The appointment of a Personal Assistant has very materially facilitated the working of the section and, at the same time, has greatly increased the volume of results obtained. During the months July to September 1911 and during May and June of 1912, when I was at Quetta, the Second Assistant, Moulvi Abdur Rahman Khan, was in charge of current work at Pusa and I have pleasure in reporting that he carried out his duties in a very satisfactory manner. The monsoon season of 1911 was a difficult one due to the excessive rainfall, but in spite of this the tobacco crop was good and the rest of the land in the botanical area compared favourably with anything I saw in the neighbourhood on my return to Pusa at the end of September. The work of the rest of the staff was satisfactory.

Part II.

Wheat Investigations.

The wheat investigations at Pusa have been extended during the past year and results of considerable value have been obtained.

Trials of Pusa Wheats in India.

During the *rabi* season of 1911-12 extensive trials of wheats were made in most of the important wheat tracts of India. As these trials have, in many cases, passed the experimental stage and the wheats are being grown on a large scale for seed distribution, the present seems a fitting opportunity of summing up the results so far obtained and of giving a connected idea of this portion of the wheat investigations.

One of the first results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities similar to those of the best wheats on the English market could be grown to perfection in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were produced which gave upwards of 2,500 lbs. of grain to the acre without irrigation or manure. In one case, a yield of 2,832 lbs. to the acre was obtained at Pusa. These new wheats were then thoroughly tested in England, both in the mill and bakehouse, and were found to behave like Manitoba spring wheats, which are in greatest demand for bread-making in England and which command the highest prices on the Home markets. In this portion of the work I was fortunate enough to secure the co-operation of Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers.

The next stage in these investigations was to extend the trials to other wheat-growing areas in India. These were carried out during the *rabi* seasons of 1910-11 and 1911-12 and the results are summed up below.

United Provinces.—As most of the wheat exported from India is grown under irrigation, it was important to ascertain by actual trials whether high grain quality and high yield could also be obtained under canal irrigation. Fortunately in this portion of the investigations the active co-operation of Mr. H. Martin Leake (Economic Botanist

to the Government of the United Provinces) was secured and extended trials of the Pusa wheats have been carried out during the past three years at Cawnpore. The results obtained were most satisfactory. In the first place, it was found that yields over 2,200 lbs. per acre and in one case as high as 2,500 lbs. could be obtained with one watering, that is, with one-third the water usually employed by the cultivators in the neighbourhood. In the second place, the appearance and milling and baking qualities of the wheats were at least equal to those grown at Pusa under *barani* conditions. This was the verdict of Mr. Humphries, who, in 1911, tested the same kinds grown at Cawnpore under canal irrigation and at Pusa as a dry crop. During the last *rabi* season, one of the Pusa wheats was grown at Cawnpore without any irrigation water at all and a yield of 1,650 lbs. to the acre was obtained, a remarkable result in a canal-irrigated tract.

The Cawnpore trials, which had extended over three seasons and which were uniformly successful, were repeated on a small scale on the Aligarh Farm in 1910-11 and again in 1911-12 on a large scale by Dr. Parr, Deputy Director of Agriculture. The yields obtained during the last season are given in the table below.

Trial of Pusa wheat at Aligarh, 1911-12.

Name.	Yield in lbs. per acre.
Pusa 22	2,098
Pusa 8	2,139
Pusa 12	2,510

During the last *rabi* season the Pusa wheats have been grown on a considerable scale by the tenants of the Court

of Wards Estates in the District of Kheri. The following are some of the results obtained by these cultivators :—

Results of the Pusa wheats grown by ryots under the Court of Wards Estate, Kheri.

Name of wheat.	Name of estate or circle.	Previous treatment of land.	Yield per acre in lbs.
Pusa 12 .	Kaimalua . .	Unmanured .	2,222
Pusa 12 .	Rajapore . .	Ditto . .	1,619
Pusa 101 .	Mankapore . . .	Ditto . .	2,057
	Bhulanpore . .	Ditto . .	1,935
	Amirtaganj . .	Manured . .	1,285
	Rasulpanah . .	Ditto . .	1,563
	Tendhua . .	Ditto . .	1,234

It will be seen that in the United Provinces the trials have extended over three years at Cawnpore and two years at Aligarh and the wheats have also been grown by cultivators. In all cases they have been successful.

Punjab.—At the Gurdaspur Experiment Station in the Punjab during the past wheat season, the following results were obtained under strict *barani* conditions on unmanured land by Mr. Milligan, the Deputy Director of Agriculture. These results are the immediate outcome of the application of improved methods of wheat growing to the *barani* tracts of the Punjab.

No.	Grain in lbs. per acre.	Bhusa in lbs. per acre.
Pusa 12 . .	2,122	3,989

On the canal-irrigated tracts of this Province the methods of growing the crop to perfection, which have

proved so successful at Cawnpore and Aligarh, have not yet been worked out. One point, however, has been demonstrated. In 1911, it was found that high quality Pusa wheats grown by tenants of the Lyallpur Farm retained their milling and baking qualities. There is every hope that provided proper care is taken in cultivation and in the use of irrigation water, results similar to those of Cawnpore can be obtained in the Canal Colonies of this Province.

Central Provinces.—As the soil conditions of the wheat-growing tracts of Peninsular India are quite different from those of the alluvium of the Indo-Gangetic plain it appeared probable that the Pusa wheats, most likely to be suitable for the black soils of the Central Provinces, would be found among the rapidly maturing varieties. Accordingly, these have been tested at Tharsa and Raipur by Mr. Clouston and one kind was tried on a small scale at Hoshangabad this year by Mr. Evans. The results are given below.

Trial of Pusa wheats, 1911-12, in the Central Provinces.

Name.	Yield per acre.	Remarks.
Pusa 12 . .	885	
Pusa 107 .	769	
Pusa 108 . .	750	
Pusa 4 . .	645	Damaged by hail.

The yield of the local kinds in the Central Provinces rarely exceeds 600 lbs. per acre and both at Tharsa and Raipur the Pusa wheats gave a larger outturn than any of the other varieties tried, while in rust resistance and grain quality they proved distinctly superior.

As regards the quality of the Pusa wheats grown in the Central Provinces, one, Pusa 4, was in 1911 tested in England by Mr. Humphries who reported: "The Raipur unirrigated lot is truly superb in appearance, indeed I do

not think I am exaggerating if I say it is the finest looking lot of Indian wheat I have ever seen." As regards the bread made from this wheat Mr. Humphries said : " In hue and general appearance of crust and crumb the Raipur lots are of the very highest class, but on the one point of strength they are really good without being extraordinary, judged by the standard of typical London flour." These opinions were confirmed by Messrs. Ralli Brothers, who valued Pusa 4 higher than any of the large collection of Indian wheats grown at Raipur in 1911. It is probable that this wheat will be of the greatest use in the Central Provinces on light soils and in years when the soil moisture is short as it ripens in the second half of February and fully a month before the local wheats. Next year it is being tried by Mr. Evans in the Jubbulpore District where a rapidly maturing late sown wheat is required on the embanked wheat lands.

Bihar.—The first trial of Pusa wheats in Bihar was made at Mia Chapra Estate in 1909-10 when 1,975 lbs. to the acre of Pusa 20 were obtained after maize the same year. All the seed was sown the following year on this estate and the resulting crop was disposed of at Rs. 5 per maund as seed wheat.

In 1910-11, several other estates grew Pusa wheats on a small scale and in all cases the yield was greatly in excess of that given by country seed. The success of these trials on a small scale led to a great demand for seed after the harvest of 1911.

During the past season, the trials were considerably extended and about 1,500 acres of land were sown with the new wheats. Some of the results are to be found in the following table and on the average the yields obtained are at least twice that given by the local wheats. The growers are very pleased with the results and are keeping the bulk of their harvest to sow an extended area next year. It is anticipated that between 10,000 and 15,000 acres will be sown with Pusa wheats next year.

Trial of Pusa wheats in Bihar in 1911-12.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 20 .	Bowarrah Concern .	1st class wheat land.	1,975	
	Ditto .	2nd class wheat land.	1,483	
	Mia Chapra Concern, 1909-10.	1st class wheat land.	1,975	
	Mia Chapra Concern, 1911-12.	Do.	2,468	
	Belsund Concern .	Medium .	1,619	
	Bowarrah Concern .	Fairly heavy	1,240	
Pusa 6 .	Motihari Concern .	Light loam .	1,839	
	Belsund Concern .	Medium .	1,730	
Pusa 8 .	Hathowri Concern .	1st class wheat land.	2,017	
	Munjhoul Concern .	Light .	1,218	The Manager states that the soil was too light for wheat.
Pusa 12 .	Mooktapore Concern	Medium .	1,481	Patna wheat sown in the same field gave only 1,028 lbs.
	Rewari Concern, 1910-11.	Land seethed	1,199	Late sowing affected the yield.
	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
Pusa 8 and 12 mixed.	Motihari Concern .	Light loam .	1,693	Yield affected by laying due to storms.
Pusa 101 .	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
	Jugolia Concern .	*Mat'ar* green manured.	1,351	Wheat laid and consequently yield affected by over-manuring.

Trials of Pusa wheats in Bihar in 1911-12 —contd.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 104 .	Belsund Concern .	Poor . .	1,451	The Manager estimates the yield would have equalled Pusa 105 if land had been good.
Pusa 105 .	Belsund Concern .	..	1,798	
Pusa 106 .	Hathowri Concern .	1st class wheat land.	1,880	Damaged by rain and rats or yield would have been still greater.
	Birowlie Concern .	2nd class wheat land.	1,707	
	Motihari Concern .	Light loam .	1,460	
	Dholi Concern .	Light land somewhat poor.	1,174	Local wheat in adjoining field gave less than half this yield.
	Mia Chapra Concern	Medium .	1,645	
	Bogwanpore Concern	Light . .	1,234	Crop badly attacked by white-ants.
	Mooktapore Concern	Medium .	1,480	Damaged by water-logging; local wheat gave two-thirds this yield in the same field.
	Belsund Concern .	Light .	1,139	Sown on soil too light for this wheat.

All the land was unmanured unless otherwise stated.

Owing to the abnormally heavy and late "hathia" rains in 1911-12 most of the wheat in Bihar had to be sown on light or second class wheat lands as the first class wheat lands did not dry in time to plough. Much of the wheat was also sown on a wet seed bed. The yield of wheat this year at Pusa, owing to the late October rains, averaged

1,600 to 2,000 lbs. an acre instead of the usual 2,000 to 2,500 lbs.

Cultivation Experiments.—Another aspect of the wheat investigations at Pusa should be mentioned. This relates to the importance of hot-weather cultivation, clean culture and moisture conservation in crop production in the Indo-Gangetic plain. By applying the methods of cultivation, which have been found successful for wheat, to other crops, both *kharif* and *rabi*, greatly increased crops are easily possible. The Pusa results have already attracted great attention in India to improved methods of cultivation and moisture conservation and have thus been of direct use in showing one of the directions in which the land, now under crops in the plains, can be made to produce much heavier outturns. The effect of these methods is cumulative and the highest yields are not obtained till the second or the third year. The methods of cultivation referred to have been published in detail in Pusa Bulletin No. 22 and Urdu and Hindi versions have also been issued. Of these latter a second edition has been called for by Mr. Burt, Deputy Director of Agriculture, for distribution in the Central Circle of the United Provinces.

Seed Distribution.

As a result of the successful trials of the new wheats in various parts of India a great demand for seed has arisen during the past year which could only in part be met. Arrangements, however, have been made to grow a large stock of seed during the coming season which it is hoped will be sufficient for all purposes.

The seed distribution arrangements in Bihar arose out of the demonstration in wheat growing given in connection with the Tirhut Agricultural Exhibition held at Pusa in January last. After this show the Bihar Planters' Association suggested the immediate formation of seed farms on estates under my supervision so as to supply a large amount of seed wheat yearly. This has been done and about 1,000 acres of the new wheats will be sown on

three estates next year for seed purposes. This arrangement ensures the expansion of the work at practically no cost to Government while the estates where the crop is grown to perfection will also serve as demonstration areas and local seed farms for the cultivators in the neighbourhood. The various wheats grown will be maintained at Pusa in pure culture and whenever necessary the seed farms will be re-stocked with fresh seed.

In the United Provinces the distribution of seed is being carried out under the direction of Mr. Leake who has arranged to grow about one hundred acres at Cawnpore and Aligarh.

In the Central Provinces the work of seed distribution is in the hands of Mr. Clouston, the Deputy Director of Agriculture, who is growing Pusa wheats on a large scale at Raipur and Tharsa. Mr. Evans proposes to try one of the early maturing wheats (No. 4) in the Jubbulpore District.

At Pusa, during the past year, the amount of the seed distributed from the botanical area was 250 maunds. In future the chief work at this centre will be confined to keeping the various kinds pure and to growing sufficient seed for demonstration purposes and for re-stocking periodically the various seed farms. In addition, a considerable area of wheat land will be taken up by the numerous cultures in connection with the selection and hybridization work in progress and with variety trials.

The Influence of the Environment on Quality.

An important stage has been reached in the experiments on the influence of environment on the milling and baking qualities of wheat. These investigations are being conducted in collaboration with Mr. Leake and the results obtained up to the *rabi* season of 1910-11 have been incorporated in a paper which is now being printed. The object of these experiments is to discover to what extent high quality in grain is possible in the various wheat-growing tracts of India and for this purpose various pure lines

have been grown at a large number of stations and the produce tested. If wheat of good quality can be grown in any tract this fact is of great importance in the work of improvement as practically all the Indian wheats of commerce are poor in quality.

The principal result obtained during the year is the demonstration of the fact that wheats of good quality can be grown under canal irrigation in the alluvium and also on the black cotton soils of Peninsular India. Quality in wheat in India is not confined to the *barani* crop. Indeed at Cawnpore during the past year the samples produced under canal irrigation were better than the same wheats grown at Pusa. At Raipur, on the black cotton soil, the samples of Pusa 4 were certainly finer than that produced the same year at Pusa. Even when grown after rice and at Lyallpur by poor cultivators the wheats did not lose their milling and baking qualities.

The results with Muzaffarnagar, a soft weak wheat, obtained at the various stations are also of interest. In no case did this wheat show strength although its milling and baking qualities were improved by the cultivation it received at Cawnpore and Pusa.

These experiments also throw considerable light on the relation between yield and quality in wheat. It was found that, in any particular wheat, the conditions which produce the highest yield are those which also produce the best quality. Further, in the same wheat, high yield and high quality can be combined. A cultivator therefore, who wishes to obtain the greatest financial return for his labour, should grow to perfection a wheat which combines high yield and good grain qualities. When this is accomplished, Indian wheats will be second to none in the markets of the world.

In this portion of the work a large number of milling and baking tests were necessary. These were carried out by Mr. Humphries in England and it is fortunate that his invaluable assistance was secured. Dr. Leather kindly

undertook the large number of nitrogen determinations involved in these investigations.

Cultivation Experiments at Pusa.

In connection with the growth of wheat at Pusa several matters connected with the cultivation of the crop have been observed which have since been made the subject of experiment.

The first concerns the continuous growth of wheat without manure. This experiment is being conducted on a plot of typical wheat land, which is heavy in texture and which retains water well. The past season was the fifth year of the experiment and the yield was twenty-six maunds to the acre, an increase on that of previous years. This is the limit of the yielding power, up to the present at Pusa, of the variety grown on this plot and the results show that, after five years' cropping with wheat without manure, the natural fertility of the land is not yet affected. Indeed, the last crop was much too rank and was laid to a considerable extent by wind after coming into ear.

The next cultivation experiment is concerned with the effect of hot weather cultivation as compared with late ploughing after the beginning of the monsoon. This experiment is now in the second year and last season the difference in yield between the two plots was twelve and a half bushels to the acre in favour of early ploughing. In the first year, the difference was only six bushels, due to the fact that both plots started in a high state of cultivation. This result appears to indicate that the effect of hot weather cultivation is cumulative and that the maximum yields are not realised the first year.

Drainage is an important factor in wheat growing in the alluvium and influences both the yield and the quality. On waterlogged areas, the consistency of the sample is generally very mixed and the yield is low. An experiment on this subject at Pusa showed that waterlogging the land during the month of September previous to sowing reduced the crop fifty per cent., that is, to sixteen bushels to the acre. This was shown to be due to a want of available nitrogen,

caused no doubt by a change in the soil flora due to the waterlogging and want of air. A rice land condition seemed to have been set up in which the wheat crop did not thrive. The subject of the importance of drainage was brought to the notice of the Bihar Planters in February last in a paper read before the Association at Mozafferpore.

Breeding.

During the year a considerable amount of attention has been devoted to wheat breeding, particularly with regard to the production of new rust-resistant wheats with high yielding power and strong straw. In connection with these investigations, which have been designed to secure results of immediate practical value, some interesting facts dealing with the inheritance of characters in wheat have been elucidated. A paper on this part of the subject is in course of publication. These results, which at first sight appear to be only of theoretical interest, are in reality of practical value as they show that the gametic constitution of wheats must be known with certainty before they can be used as parents for the production of new types. Further it is desirable that all varieties of crops in India (whose behaviour in breeding is known) should be most carefully preserved at the experiment stations so that they may be immediately available for other workers.

The new experiment station at Quetta was of use in connection with the breeding work at Pusa. The variety trials in 1912 indicated that two crosses on the pure line A 88 were desirable. This could only be seen at harvest time when it was too late to make the crosses. Seed was, however, sent to Quetta in March and the crosses were made in the following June thus saving a whole year in the work

Part III.

OTHER INVESTIGATIONS.

Tobacco.

The progress reported in the previous annual report with regard to this crop has been continued during the past year.

Cultivation.—The successful growth of this crop after a green crop of *san* ploughed in was referred to in last year's report. This method of manuring was repeated on a large scale in 1911-12 and in spite of the bad season a very good crop was produced. The excessive rain at sowing time in August, followed by long continued wet weather till the middle of October, greatly interfered with the preparation for this crop. In consequence, the growth was slow and the period of ripening delayed. Even under these adverse conditions, the crop grown on *san* was superior to any tobacco fields in the neighbourhood.

Curing.—The curing experiments of the previous year were repeated on a large scale, the crop being grown after *san* ploughed in without any other manure. Three types, Nos. 28, 29 and 32, were grown and cured by a modification of the country method, care being taken to use the minimum amount of moisture in the process so as to preserve the yellow colour as much as possible. Type 28 gives a yellow colour combined with good texture and fine leaves and was reported on very favourably in 1910-11. Types 29 and 32 are heavier, coarser kinds with darker colour and large leaves. These were grown for comparison with Type 28. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 again received a very favourable report and the leaves were valued at Rs. 12 to Rs. 14 per maund which is a considerable advance on the local prices. A large quantity of self-fertilized seed of this type was grown for the Company and arrangements have been made on three estates to grow this kind next year. The results obtained with this tobacco show that a suitable leaf for cigarettes can be grown and cured in Bihar by the people and thus the first object of these curing experiments has been achieved. It now remains to get the Pusa results repeated on the indigo estates and to see whether the planters in Bihar are prepared to take the trouble necessary to grow and cure this tobacco. If they do it will then be possible to consider whether or

not fire curing in some simple form in earth-built barns can be undertaken in Bihar with any prospect of success.

Breeding.—Considerable progress was made during the year by the Personal Assistant in the investigations on the inheritance of characters in *Nicotiana tabacum* and in *N. rustica*. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be produced by hybridization. The results so far obtained are now being submitted for publication.

It is interesting to note that the earlier selection work done on the tobacco crop at Pusa and published in Nos. I and II of the third volume of the Botanical Memoirs has been repeated by the Bureau of Plant Industry of the United States Department of Agriculture and confirmed in all respects. The American results are published in a recent issue of the *Botanical Gazette* (Vol. LIII, No. 2, 1912).

Gram.

Some time ago a sample of gram was grown in the botanical area from which a number of pure lines were isolated in connection with the investigations on natural cross-fertilization published in No. IV, Vol. III of the Botanical Memoirs. Some of the more promising of these pure lines were grown in large plots in 1911-12 and the yields were carefully determined. Seven lines were grown and one plot contained local seed for comparison. The yields obtained were very high and the largest crop was nearly thirty-four maunds to the acre while two other lines gave over thirty maunds. Samples of the seed were submitted to Messrs Ralli Brothers, Bombay, for valuation and report. Four of the lines were valued over Rs. 4-8 per cwt. f. o. r. Bombay compared with Rs. 4-2, the price of the ordinary exportable varieties. The line which gave thirty-two and-a-half maunds of seed was valued at Rs. 5-8 per cwt. f. o. r. Bombay—an increase of Re. 1-6 per cwt. above the ordinary seed. These lines will be grown on a larger scale next

season and are also being tried in other parts of India. The results indicate that selection methods can be applied to gram with good prospects of success. As the flowers are self-fertilized in Bihar, it is likely that any improvement can readily be maintained.

Fibres.

The work with fibre plants has been continued, the crops studied being patwa (*Hibiscus cannabinus*), rozelle (*Hibiscus Sabdariffa*), and san (*Crotalaria juncea*).

It was found that one of the types of *H. cannabinus* grown from the seed of unprotected flowers could be freed from all hybrids in the seedling and early vegetative stages and thus could be kept pure by simple rogueing. It is possible that similar methods might be adopted in the case of cotton grown for seed distribution purposes. In the case of *san* progress was made in isolating the various varieties of this crop and a beginning was made in the study of the methods of pollination in this species.

In rozelle a considerable amount of work was done on the inheritance of characters in this crop and in the study of the second generation of the hybrids. The varieties of Indian rozelle are well adapted for the study by students of simple Mendelian phenomena and it was partly on this account that this work was undertaken.

Pollination.

Progress was made during the year in the study of the methods of pollination in the various crops of India and particular attention was devoted to some of the oil-seed crops. As soon as sufficient material has been collected these results will be incorporated in a paper.

Part IV.

The Tirhut Agricultural Exhibition.

The Tirhut Agricultural Exhibition was held in the botanical area at Pusa on January 18th, 19th and 20th,

1912, and I acted as local Secretary for the show. In addition to the usual exhibits of agricultural produce, live stock and the products of the local industries, the special feature of this Exhibition was the demonstration to planters, zemindars and cultivators. The nature of these demonstrations will be evident from the following extract from the report on the show :—

"An important departure was made this year in the Exhibition, largely through the efforts of Mr. F. F. Lyall, I.C.S., Collector of Mozafferpore. In 1910, it was suggested by the Imperial Economic Botanist that the Tirhut Exhibition should be held at Pusa once every four years and that the various improvements in Indian agriculture, shown to be possible by the work of the Pusa Institute, should be demonstrated to the planters, zemindars and cultivators of the Division in the form of growing crops of increased yield and value. This suggestion was not accepted for the 1911 show, but it was revived again by Mr. Lyall and adopted by Mr. H. C. Streatfeild, I.C.S., Commissioner of the Division. As a consequence, the Exhibition of 1912 was held at Pusa and the grounds of the Botanical Section were lent for the Exhibition. In the cultivated portion of this area, numerous plots were laid out to illustrate as many as possible of the improved methods of agriculture discovered at Pusa. The crops selected for this purpose were tobacco and wheat and, in addition, there was a further demonstration on two neighbouring plots of land belonging to ryots.

"The main demonstration to planters, which occupied about three hours, took place on the morning of the 19th January when the attendance was upwards of 50. This consisted of a series of short lectures by the Imperial Economic Botanist followed by discussions at the various plots. It was repeated in the afternoon for the benefit of those who arrived too late for the morning work. Leaflets dealing with the main subjects dealt with, were previously prepared and printed and sets of these were distributed. For the benefit of cultivators these demonstrations were given

in the vernacular, both on the 19th and 20th, by Moulvi Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist, and were largely attended. In addition to these formal demonstrations, the various members of the staff of the Botanical Section explained the work in progress to the cultivators and, in this way, a good deal of useful work was accomplished.

" The scope of the demonstrations can be gathered from the titles of the leaflets prepared for the show which were as follows :—

1. Green manuring with *san* for tobacco.
2. The improvement of wheat cultivation in Bihar.
3. The effect of grass on fruit trees.
4. The value of pure seed in India.
5. The importance of hot-weather cultivation in Bihar.

In addition, several improved implements, suitable for Bihar, were shown at work and various leaflets dealing with these machines were distributed. After seeing the spring-tine harrows at work fifty of these were ordered by the planters.

" These demonstrations were a great success and were followed closely both by the planters and by the cultivators. There is no doubt that this method of bringing home the results of the work of the Agricultural Department is infinitely more effective than publications or the exhibition of collections of seeds and other produce. An acre plot of improved wheat or tobacco for example appeals much more strongly to the agricultural mind than results in print or in the shape of collections of seed."

Part V.

The Development of the Fruit Industry of Baluchistan.

Progress has been made during the year in the work outlined in the last report in connection with the development of the fruit industry of Baluchistan.

A suitable site for the fruit experiment station was selected on the Sariab road about two miles from Quetta and the land was acquired in September 1911 by the Local Government. This was roughly laid out in terraces and plots last year, and, during the present summer, progress has been made in the final levelling of the plots and in making the necessary irrigation arrangements. Two shares in the Sirkhi karez have been purchased and two artesian bores have been laid down while a third is now in progress. These bores are 80, 150 and 250 feet in depth and tap three different water-bearing gravels. The total surface flow is expected to be well over 1,000 gallons per hour and the water will be finally collected in a pucca tank capable of holding four days' discharge. An experiment has also been made of pumping from one of these bores by means of an oil engine when the flow increased from 600 gallons to 4,250 gallons per hour. A well has been sunk which gave water at 22 feet and on this a Persian wheel is being erected. The water supply of the fruit experiment station is now assured and proposals have been submitted for laying down permanent masonry water channels for the main distribution and for carrying the zemindar's water through the area instead of in the present earth channels.

Five quarters for workmen, a cattle shed, two godowns, an implement shed and overseer's quarters were erected in 1911 as well as a building for laboratory and office work. The area has been surrounded by a wall and the road to the laboratory has been made pucca.

A portion of the land was laid out for a nursery and a number of stocks have been raised for budding during the present year. Some of the land was sown in *shaftal* for fodder and green manure.

The old fruit garden in Quetta was handed over on October 1st, 1911, and a beginning was made in getting this into order and in removing old trees. A portion of the area was got ready for *shaftal* and good crops were produced. Another portion was prepared for an experiment

in the growing of tomatoes on improved lines. During the present year, further progress was made on the work of renovation and it is hoped to get at least half of the land ready for a clover crop this autumn. Next year it is proposed to plant this area up in fruit trees.

A considerable amount of work was done in 1911 in working out the best methods of transporting fruit to India. It was found that the cheapest and best packages were those made up with chip and boards imported from Glasgow. Returnable boxes made of venesta wood were found to be impracticable under Indian conditions on account of the frequent overcharges and mistakes made by the Railway Companies in sending the empties back to Quetta. Any one sending returnable fruit boxes on Indian Railways on a large scale would have to keep at least one clerk to check the charges and to file claims. Another difficulty in connection with sending fruit by rail was the numerous thefts on the trains. If a merchant sending fruit from Quetta were to complain every time these thefts occurred, another extra clerk would be required for the correspondence that would be involved.

As a result of last year's experiments non-returnable boxes for the five-seer rate were designed and steps were taken to import a supply of material for these sufficient to meet the demands for 1912 and 1913. In addition, a supply of other boxes for experiments with tomatoes and other fruits was imported.

In carrying out the work at Quetta I have been greatly assisted by Mr. H. R. C. Dobbs, C.I.E., Officiating Revenue Commissioner in Baluchistan, who did a great deal to further the work after my departure in September 1911. Colonel McConaghey, C.I.E., the Political Agent at Quetta, has also rendered valuable assistance, while the work connected with the artesian bores and the pumping experiments was only possible through the ready help given by Colonel Williams, R.E., Secretary to Government in the Public Works Department, and by Colonel Picton,

A.C.R.E., Quetta. Colonel Duke, I.M.S., Residency Surgeon and Chief Medical Officer in Baluchistan, was kind enough to receive and plant out a number of young trees. He has also helped me by giving me the benefit of his local knowledge of fruit growing and of the practices in vogue in Persia.

My third assistant, Munshi Ijaz Husain, worked well at Quetta in the autumn of 1911 when left in charge of the work.

Part VI.

Programme and publications.

Programme of work for 1912-13.

1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant Breeding and Plant Improvement.*—During 1912 the following crops will be studied :—wheat, tobacco, oil-seeds and fibre plants.

(*a*) *Wheat.*—The production of improved and rust-resistant types by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.

(*e*) *Fruit.*—The fruit experiments at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

The pressure of current duties has again delayed the publication of results and only a few papers could be written during the year. The work of the section, particularly on wheat and tobacco, has increased beyond all expectations during the past two years and it is difficult to find sufficient free time for writing papers and for correspondence.

The following papers were published or written during the year :—

1. Green manuring with *san*. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
2. A suggested improvement in sugar-cane cultivation in the Indo-Gangetic plain. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
3. The improvement of Indian wheat. *Journal of the Bombay Natural History Society*, October 1911.
4. A Hindi and Urdu version of Pusa Bulletin 22 on the production of wheat in India.
5. The Botanical aspect of the improvement of sugar-cane in India. *International Sugar Journal*, 1912.
6. The production and maintenance of pure seed of improved varieties of crops in India (with G. L. C. Howard). *Agricultural Journal of India*, Vol. VII, Part II, 1912.
7. Report on Economic Botany for 1910-11 for the Board of Scientific Advice (with R. S. Hole).

8. Some aspects of the Agricultural Development of Bihar—an address delivered to the Bihar Planters' Association at Mozaffarpore on January 31st, 1912.
9. The influence of environment on the milling and baking qualities of wheat in India, No. 2 (with H. Martin Leake and G. L. C. Howard). *In the press.*

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

1. *Charge and Establishment.*—I remained in charge of the section until June 16th, when I proceeded on 20 days' privilege leave, Mr. F. J. F. Shaw officiating. In addition to my own duties, I also held charge of the post of Director of the Agricultural Research Institute, Pusa, until March 31st. Mr. Shaw held the post of Supernumerary Mycologist throughout the year. Mr. J. H. Mitter, Second Assistant, reverted from the Punjab Department of Agriculture on the abolition of the post of Assistant Professor of Mycology at Lyallpur, which he had held since May 1910, on November 24th. He has again joined the Punjab Department to officiate as Assistant Professor of Botany for three months from June 15th. All the staff have worked well.

2. *Training.*—Babu K. C. Banerji, B.A., L.Ag. (Nagpur), was sent for training in Mycology and Entomology by the Bihar and Orissa Department. He attended the section from February 22nd. Lala Bishambar Das, M.Sc., Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory for about six weeks during his college vacation in July and August.

3. *Aid to Provincial Departments.*—A considerable number of parasitic fungi were named for the college collections in the various Provincial Departments, especially for Bombay, Bengal and the Punjab. The manuscript of the mycological portion of a Handbook of the diseases and pests of cultivated plants in Bengal was read through and annotated. Several blocks of original figures suitable for illustrating this book were lent to the Economic Botanist, Bihar and Orissa. Some manuscripts containing results of scientific work by the Assistant Professor of Mycology and the Mycological Assistant, Poona, were read and advice given as to the best means of publishing them.

4. *Plant disease investigations.* (a) *Paddy diseases.*—Considerable time has been given to the investigation of a disease of standard paddy, locally known as *ufra*, in the Cuttack districts of Eastern Bengal. The disease is said by the cultivators to have existed for at least a generation, but it appears to have greatly increased in virulence in recent years, and has been under the observation of the Eastern Bengal Department of Agriculture since 1905. It was attributed by different observers to insects, fungi and unfavourable soil conditions. A complete Entomological and Mycological investigation was undertaken last December when Mr. Fletcher, Officiating Imperial Entomologist, and myself visited Southern Orissa. The result was to exclude insects as the direct cause and to throw suspicion on a worm of the Nematode class always found living on diseased plants. This worm, a *Tylenchus*, member of a genus whose species are already known to cause several serious diseases of cereals (of which "ear cockle" in wheat is perhaps the most familiar), is exceedingly minute, practically invisible to the naked eye, it is found in clusters, often containing many individuals, on the surface of diseased parts. The anterior end is provided with a sharp spear and a sucking apparatus by which the juice of the living cells of the plant is made use of as nourishment. At least two, probably more, complete life cycles occur in a year and, as the female lays a large number of eggs, increase is rapid. On diseased plants the worms are found in the early stages occupying small brown patches on the leaves and culm. As the crop approaches maturity larger numbers of worms occur on the peduncle of the ear and just above the next lower node. At these points the stem is deep brown in colour and shrunken to little more than the thickness of a thread. Still later, worms are found within the empty glumes of the lower flowers and the ears generally bear no grain. A frequent condition is the failure of the ear to emerge from the enclosing sheath and to this the name *thor* by which *ufra* is applied, from the swollen appearance of the seed of the plant. In years *ufra* the ears

emerge, but are light and bear no grain. In Begumganj Thana of Noakhali District about half the crop was lost last year; several fields were visited which had not been considered worth harvesting. In 1910 it is estimated that the loss in this Thana was 200,000 maunds of grain. Outside Noakhali, the disease is said to occur in Comilla, Chandpur and the neighbourhood of Dacca and is probably more widely distributed than this. The same worm was found in specimens collected in these localities and the symptoms were similar. Elsewhere, from several of the rice-growing tracts of India, reports and specimens of diseases exhibiting points of resemblance to *ufra* have been received, but examination has not, so far, revealed the occurrence of true *ufra* outside Eastern Bengal. Further work is required to ascertain if the worm must be held directly responsible for the disease and, if so, how it can be checked. Experiments in this direction are in progress in collaboration with the Bengal Department.

An unsuccessful attempt was made to trace by field inoculations the life history of the "false" smut of rice caused by *Ustilaginoidea virens*. This is being repeated this year.

(*b*) *Root rot of plants due to Rhizoctonia.*—The soil-dwelling parasite *Rhizoctonia* has been known in Europe as a fungus pest since the early part of the eighteenth century. It attacks chiefly subterranean tubers such as potato, saffron, carrot and beet; in America it is also found on cotton. The researches of the past two years, carried out by Mr. Shaw and an account of which is now in the press, have shown that, in India, it is a parasite of wide range and, in some cases, extreme virulence. The species known as *Rhizoctonia Solani* Kühn, first described in 1858 on potato, appears to be most common. It occurs on potatoes at Bankipore, and on the Pusa Farm attacks jute, groundnut and cowpea. At Cawnpore it attacks seedling cotton and it has been reported on sesame from Surat. In some cases, *e.g.*, jute and cotton, the attack takes place in the seedling stage, when it is particularly virulent, in the case of jute the death rate in pot-culture being 70—80 per cent. The attack on cotton

was of interest as it proved to be identical with that known in Egypt as "sore shin" and in America as "damping off," both of which diseases were attributed by their investigators to an unnamed sterile fungus.

Special attention was paid to the possibility of the existence of biologic forms within the morphological species *R. Solani*. It was found that the race on jute was markedly different in its infective power from the fungus on cowpea, groundnut and cotton. The former would only infect its own host whereas the fungus upon either of the other three hosts could infect any one of the remainder.

A second species of *Rhizoctonia*, possessing much larger sclerotia, was found on groundnut and cowpea. It soon became clear that great confusion existed in the published literature between these two forms, which have been attributed to a single species under the name *Rhizoctonia violacea* Tul. The second form also occurs sometimes on potato, where it has been identified by American writers as *R. Solani* and stated to have a Basidiomycete, *Corticium vagum*, as its perfect stage. The investigations of the last year have confirmed the latter point but have shown that the fungus associated with *Corticium vagum* is a distinct and separate species. It is suggested that the name *R. violacea* may be retained for this form.

The fact that *Rhizoctonia* may live in the soil of an infected field for years renders the disease a peculiarly difficult one to combat. In Egypt a dressing of naphthalene has been found very beneficial in the case of cotton, while in England a weak solution of carbolic acid applied to the soil has given good results. The latter method is, however, too expensive for general use. It is fortunate that, so far, cereal crops appear to be immune to this disease and a careful rotation of crops is probably the best method of lessening its ravages.

(*c*) *Wheat rust*.—Last year was marked by a severe attack of wheat rust, the first for a number of years, in the Central Provinces. The disease was also prevalent in some

other wheat-growing areas, notably in Rajputana. Munshi Inayat Khan, senior Fieldman, was deputed to collect specimens and notes in the Central Provinces at the end of March. Examination at Pusa showed that, while all three varieties of rust were present, most of the damage was caused by " orange " rust (*Puccinia triticina*) and " black " rust (*Puccinia graminis*); " yellow " rust (*Puccinia glumarum*) was much less in evidence. Previous experience indicates that, in normal years, orange rust is absent or scarce in the Central Provinces, though common in Bengal and parts of the United Provinces. It appears, therefore, that in bad years this rust extends its area and much of the losses in 1912 must be attributed to it. In breeding rust-resistant wheats for the Central Provinces, yellow rust need not at present be taken into account. Black rust is always present and does much damage even in normal years; wheats resistant to this rust would be of undoubted value. As regards orange rust, the growth of wheats which withstand this variety would be a form of insurance against the occurrence of a rusty year. It is not, unfortunately, as yet definitely known whether wheats resistant to all three rusts can be produced. Meanwhile, as it is not possible in ordinary years to study the susceptibility of Central Provinces wheats in regard to orange rust, wheats which resist this rust in localities where it is prevalent might with advantage be introduced into the province.

(*d*) *Phytophthora investigations.*—Two species of this most destructive genus of fungus parasites have been under special study in the section. The first is *Phytophthora Colocasiæ* Rac., which attacks the common indigenous vegetable *kachu* (*Colocasia antiquorum*) throughout South-Eastern Asia. Its study was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909. It has since been continued by myself and its successful growth in artificial culture last year has allowed of the complete working out of its life history. It is hoped to publish the result of this work shortly. Mr. Dastur, First Assistant, has taken up the study

of a *Phytophthora* which attacks castor, as part of a larger investigation of the diseases of this crop. This species has also been got into artificial culture. The simultaneous production of the saprophytic habit by artificial culture in two species of this genus, until recently supposed to be exclusively parasitic, has permitted of important additions to our knowledge of the biology of the genus. *Phytophthora infestans*, the cause of the well-known potato blight, was found attacking potatoes and tomatoes at Jorhat in Assam; on a previous occasion, in 1902, it attacked potatoes in Burdwan and Hooghly Districts in Bengal. Ordinarily confined to temperate climates and always prevalent in the Hill Tracts of India, it is, perhaps, to be feared that a race is being developed which can withstand the heat of the plains.

(*e*) *Sugar-cane diseases.*—A memoir giving the results of the work of the past few years has been commenced. The difficulties encountered in carrying on field experiments, owing to inability to control external conditions which caused the partial loss of the crop on several occasions, have led to much loss of time. A good deal of information has, however, been obtained as regards methods of infection other than by planting diseased cuttings, both in red-rot and *Cephalosporium* disease, and it is considered advisable not to delay publication. This year's work includes these two diseases and also smut. Early in 1912 specimens of a cane disease which has appeared on the Jorhat Farm were received from Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, who laid stress on its resemblance to *sereh*, the disease which has caused more damage in Java than probably any other of the numerous diseases of this crop. The resemblance is indeed striking and a recent visit to Jorhat has not enabled me to identify the disease with any of those known in India. The symptoms of *sereh* are elusive, its cause is unknown, its treatment very troublesome; and the accurate identification of the Jorhat disease, so that measures for its suppression may be taken if necessary, is obviously a matter of the first importance.

(*f*) *Palm diseases.*—The "plague" of betelnut palms in Bengal and Assam has continued to spread to the north and east since first reported to Sir George Watt in 1896. Since 1905, when I visited Sylhet to attempt to discover its cause, it has extended to Cachar and Goalpara. Specimens from these districts, and from Khulna at the other extremity of the affected area, were examined during the year. The cause appears to be the fungus *Polyporus* (*Fomes*) *lucidus;* this species occurs commonly on dying palms and reasons were given in 1905 for supposing it to be parasitic. More recently it has been found on diseased areca and cocoanut palms in Mysore and Ceylon, and though its parasitism has not been conclusively proved, it is considered to cause disease in both localities. The losses in North-Eastern India have been enormous, but the area affected is so large as to render impracticable any attempt to check it on the lines of the successful work against bud-rot in Madras. The application of lime has been recommended and is reported to have had a beneficial effect.

(*g*) *Tea diseases.*—Mr. Shaw visited Cachar in December to investigate tea canker. The cause of this disease still, however, remains obscure. An *Exobasidium*, closely allied to that which causes "blister-blight" of tea, was discovered by Mr. I. H. Burkill in the Khasia Hills on *Camellia drupifera*, a wild relative of tea. I had some hope that this would serve to explain the spread of blister-blight from North-Eastern Assam to Darjeeling, but on submission to a specialist it was found to be a distinct species. Blister-blight was severe in parts of Assam this season and suggestions for further experiments to aid in its control were given to enquirers. The Scientific Department of the Indian Tea Association published an account of the suggested connection between the tea-seed bug (*Pœcilocoris latus*) and the fungus infection of tea seed, based on work carried out by me in the previous year. The section has been freely consulted by that Department during the year.

(*h*) *Indigo disease.*—A recrudescence occurred towards the end of last season of the so-called "wilt" of Java indigo

in Bihar, particularly where "moorhun" plant was kept for seed bearing. As there is much confusion between the condition due to the insect pest *Psylla* and that known as "wilt," a conjoined mycological and entomological investigation was undertaken. I visited the Research Station of the Bihar Planters' Association in November and examined the crop which had been kept for seed and which was at this date almost entirely destroyed. No sufficient explanation of the death of the plants could be found and it appears unlikely that it is due to a definite fungus parasite. As, on the other hand, it appears to be quite clear that Psylla does not kill the plant in this fashion, it is evident that further investigation is necessary. The preliminary stages of this were commenced last year.

(*i*) *Forest tree diseases.*—A large number of specimens of diseases of forest trees were received from the Forest Department. These included various pines, deodar, shisham, teak, "nahor," *Casuarina*, "sal," "mahua," *Cassia fistula*, mulberry, etc. In several cases the diseases were due to parasites already known and suggestions for treatment could be given. In others, notably the *nahor* disease in the Sibsagar and Teesta Divisions, the cause is a fungus which it has not yet been possible to identify and no recommendations can be made.

(*j*) *Other plant diseases.*—I visited Lyallpur in October to investigate the cause of the death of cotton plants in certain areas of the Government Farm. No parasite was found but evidence was obtained to show that the damage was due to root injury, resulting from the presence of an impermeable stratum some distance below the surface of the soil. A large number of specimens of cotton plants from fourteen villages in the wilt-infected area in Berar were sent for examination by Mr. Clouston. The percentage of wilt varied from over fifty to three. *Buri* cotton, so far, remains immune and Mr. Clouston is now working out how far this advantage compensates for its lower yield as compared with the varieties commonly grown. Mr. Shaw has investigated the disease of Sisal caused by *Colletotrichum*

Agaves and has prepared a note for publication. He also visited the Sisal plantation of Messrs. Allen Brothers near Cawnpore to report on its health. An outbreak of lucerne mildew was reported from the Remount Depôt, Sargodha, and of cauliflower mildew from Lahore. Experiments were continued with a view to finding some practical method of checking anthracnose of plantains. The stem rot of papaya was also under study, as its cause has not yet been determined. Mr. Shaw made a local investigation of the orange disease in the Khasia Hills, whence the " Sylhet " oranges of the Calcutta market are exported. The cause of this very obscure disease is still unknown. Oat smut was prevalent in Bihar and recommendations for its treatment have been made. A disease of coffee berries from Coorg was found to be caused by *Colletotrichum Coffeanum* Noack, a parasite which I had previously observed attacking the leaves of this plant, but which was not known to attack the berries. Mr. Shaw has commenced the study of *Striga*, a parasitic flowering plant which does much damage to sugar-cane, jowar and other Gramineæ in India. Amongst the diseases not previously known in India, cotton anthracnose, lucerne mildew and rust of velvet beans were the chief. Two diseases of wild vines were investigated, one of which is known to attack also the cultivated species. An account of them was published since neither occurs in Europe and, if introduced, they might prove serious pests in grape-growing countries. The usual routine work of dealing with enquiries and specimens sent in for report was continued. Altogether 98 parcels of specimens were examined.

5. *Systematic work.*—A considerable advance was made in this branch of the work of the section, the additions to the named herbarium collection numbering some hundreds. These were for the most part plant parasites, about 200 additions to the parasitic flora of India having been made. Two parts of the list of Indian fungi, which is being prepared in collaboration with Messrs. H. and P. Sydow of Berlin, were published. These contained the record, and in many cases also a detailed description, of over 300 species of

Indian fungi, of which more than a hundred were new to science. An account of an interesting aquatic fungus was also published. The total number of mounted sheets added to the herbarium was 779.

6. *Miscellaneous.*—I attended the meetings of a committee appointed to consider the question of preventing the importation of noxious insects and plant diseases into India, held at Pusa in November. It is greatly to be desired that action in this direction should be taken without delay. The measures recommended last year for checking the spread of lantana, a noxious weed in Mysore and Coorg, are under consideration and further information has been supplied to the authorities concerned. The section fitted up a stall at the Tirhut Agricultural and Industrial Exhibition held at Pusa in January, which was well attended. Assistance was given to the Government College, Lahore, in providing material and notes for teaching elementary mycology. An outbreak of dodder in clover was reported from Peshawar and recommendations for its suppression were made. I wrote the chapter on Mycology for the Annual Report of the Board of Scientific Advice for the year 1910-11.

7. Programme of work for 1912-13.

(*1*) *Research and experimental work.*—The investigation of the disease of paddy known as *ufra* in Bengal will be continued. Other diseases of paddy will be taken up as opportunity occurs.

Work on sugar-cane diseases will be continued. The disease which has appeared on the Jorhat Farm will be specially studied with a view to determining whether it is *sereh*.

It is proposed to examine the wilt diseases of cotton and sesame, in the Central Provinces, with a view to ascertaining their causes.

It is hoped to conclude the investigation of two species of *Phytophthora* and the diseases of castor and *Colocasia* caused by them.

The study of the so-called " wilt " of indigo will be continued.

The Supernumerary Mycologist is engaged in an investigation of some Phanerogamous plant parasites, especially *Striga*.

(*2*) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(*3*) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will be continued.

(*4*) The collection and identification of Indian parasitic fungi will be continued.

8. Publications.

Fungi Indiæ Orientalis, Part III, H. & P. Sydow and E. J. Butler. Annales Mycologici, Vol. IX, No. 4, 1911; *ib.*, Part IV, Vol. X, No. 3, 1912.

On Allomyces, a new aquatic fungus, E. J. Butler. Annals of Botany, Vol. XXV, October 1911.

The rusts of wild vines in India, E. J. Butler. Annales Mycologici, Vol. X, No. 2, 1912.

A disease of Cotton, F. J. F. Shaw. Mufid-ul-Mazarain, September 1911 (*vernacular*).

Copper Blight of Tea, F. J. F. Shaw. Quarterly Journal of the Scientific Department, Indian Tea Association, Vol. I, Part 3, 1911 (reprint).

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(A. J. Grove, M.Sc.)

1. *Charge and Establishment.*—The Imperial Entomologist, Mr. H. Maxwell-Lefroy, was away on long leave during the whole of the period under review. Mr. T. Bainbrigge Fletcher held charge of the section until April 19th, when he proceeded to Coimbatore to take up his new appointment as Entomologist to the Government of Madras. I joined my appointment as Supernumerary Entomologist on October 27th, 1911, and, since Mr. Fletcher's transfer, have carried on the work of the section. The First Assistant, Mr. C. S. Misra, has been in charge of all the field-work on the Pusa Farm and the botanical area, and of the arranging and carrying out of the lac work including the giving of two short courses in Lac cultivation. He has also assisted in the instruction of students in General Entomology and field-work. In addition to this heavy routine work, he has continued his investigations on the *Aleyrodidæ* and other Hemiptera. The Second Assistant, Mr. C. C. Ghosh, was on privilege leave from May 6th to June 30th, 1912. He has been in charge of the Insectary and has continued to carry out extremely useful work on many insect pests. Mr. G. R. Dutt, Third Assistant, has had the Economic Collections, records, correspondence and the distribution of coloured plates and lantern slides in his charge. In August 1911, he was sent to the Punjab and remained there for nearly three months organising and directing the campaign against the Cotton Bollworm. In this and his other work he has done admirably. Mr. Nowrojee, who was away on privilege leave from December 15th, 1911, to January 14th, 1912, has been in charge of the general collections and has done good work in arranging and keeping them in order. Mr. M. N. De had charge of the Silk House and has shown much interest in the work.

2. *Visitors.*—Mr. A. E. Andrews, Entomologist to the Indian Tea Association, worked in the Laboratory during the latter part of December and the beginning of January and again in February. Dr. A. D. Imms, Forest Zoologist, visited the section for a short time in January. Dr. H. Morstatt, Entomologist at Amani, German East Africa, worked for a time in the Laboratory. Mr. Johann Lang of the Basel Mission, Calicut, came to Pusa to acquaint himself with the details of Eri Silk culture and spent a short time working in the Silk House. Mr. Akhtar Mohammad Khan, Deputy Collector in the United Provinces, on special duty for silk work, visited Pusa during March to consult with the Officiating Imperial Entomologist.

3. *Training.*—The Assistant Professor of Entomology at the Lyallpur Agricultural College continued his course of training, but was recalled to his Province before this was completed. The Entomological Assistant in the North-West Frontier Province, after completing his course, remained working in the Laboratory until October 14th, 1911, and again from December 1st, 1911, till February 22nd, 1912, preparing show-cases of insect pests found in his Province. An Entomological and Mycological Collector to the Department of Agriculture, Bengal, was trained in Economic Entomology from August 10th, 1911, to February 22nd, 1912. A private student deputed by the Department of Agriculture, Travancore, for a course in General Entomology, was admitted on June 1st, 1912. Seventeen students attended the short courses in Sericulture; seven completed their course and five are still being trained. The two courses in Lac cultivation were attended by thirteen students.

4. *Provincial Work.*—The importance of work in the Provinces is now fully realised as indicated by the appointment of an Entomologist to the Government of Madras. There are, however, only eighteen assistants working in the Provinces and two are still under training. Under these conditions the progress of the work of demonstrating to the

agricultural classes the principles of Economic Entomology must necessarily be slow. Pusa has continued to assist the Provinces, whenever requested, by checking and advising upon the work of the assistants and in many cases the technical work has been referred to Pusa, leaving the assistants free to carry out practical work in the field.

In Madras a vigorous campaign was carried on against the Deccan Grasshopper, *Colemania sphenarioides*, Bol. Bagging and ploughing of infested lands were carried out and a leaflet detailing the methods to be adopted against the hopper was issued. Light-trap experiments for the moths of the Hairy Caterpillars were also continued. Eri Silk culture was started and its suitability as a cottage industry for Southern India tested.

In the Central Provinces, the experiments against white-ants were continued in collaboration with the Deputy Director of Agriculture, Northern Circle, Hoshangabad. From past experiments with the mound-building form of termites, oiling the nest with low grade kerosine oil (as ordinarily procurable in the bazaars) was found most effective. Tests were also made with the " Universal Ant Exterminator." Arrangements were also made with the Director of Agriculture, Central Provinces, for the despatch of parasites of the Cotton Bollworms to Lyallpur, and for some time the Entomological Assistant was engaged in collecting and sending out the parasitized bollworms to Pusa and Lyallpur. Early in August information was received from the Director of Agriculture, Punjab, of a possible outbreak of the bollworms. Arrangements were therefore made for sending out the parasites from Surat and Nagpur to an assistant from Pusa to organise the work at Lyallpur. An acre under cotton and two acres under *bhindi* were also sown at Pusa to establish the bollworm parasites. By the end of October the parasite (*Rhogas lefroyi*) was well established in the Punjab and a leaflet was issued in the vernacular of the Province, explaining how the bollworm should be dealt with.

In the United Provinces, active measures have been adopted against the Rice Grasshopper, *Hieroglyphus furcifer*, a serious pest to sugar-cane.

In Bengal successful demonstrations were made against the Potato Moth (*Phthorimæa operculella* Zel.) and the advantages of storing seed-potatoes under sand were demonstrated to the Kaoris as well as to others engaged in the potato trade. A leaflet, explaining the methods to be adopted against the moth, was distributed at Tirhut and Bankipore Exhibitions. The campaign against *Agrotis ypsilon* was continued. The picking off of the first brood of caterpillars and the setting up of Andres-Maire traps reduced the loss during the past year to a minimum, so much so that out of a total area of 20,000 bighas, only 2,000 were affected. Eri work was begun and the Department completed a Crop-pests Handbook.

In Eastern Bengal and Assam, the *Ufra* disease of paddy, probably caused by an eel-worm, was investigated.

In Baroda, the campaign against the *Katra* (Hairy Caterpillar) was continued. Practical demonstrations were made and rewards were offered to cultivators for keeping the field embankments clean as a preventive against the pest.

In the North-West Frontier Province, on the resumption of duties by the Entomological Assistant, a survey of the crop-pests of the Province was started and effective measures were taken against the Peach and Tobacco Aphides.

5. *Correspondence.*—The work of replying to the numerous requests for information and advice on the many branches of entomological work continues to demand much time and attention, but in view of the importance of this part of the work of the section, no efforts have been spared to give applicants as full information as possible. Seventy-eight parcels of insects were received for identification and suggestion of methods of treatment and this was done as far as we were able in each case.

6. *Research.*—The investigation of the habits and biology of insect-pests has been continued and among those studied may be mentioned the " Bherwa," the Fish Insect, White Weevil, Mango Leaf Hopper, Surface Grasshopper, Parasites of Cotton Bollworms, Cane Borer, Cane Fly, Wheat Stem Borer, Termites, Grain and Flour Beetles. The experiments on the preservation of wood and other materials from the attacks of Termites (white-ants) are still in progress and the efficacy of various preparations and the relative immunity of different kinds of woods are being tested. At the request of the Bihar Planters' Association, an investigation into the " Psylla " disease of indigo was commenced and is being continued.

7. *Insecticides.*—A number of preparations sent in for trial were tested and reported on. The first edition of Bulletin No. 23 on insecticides speedily ran out of print and a second edition revised and with some additions has been published. As many inquiries have been received as to where various insecticides and spraying machines were obtainable lists of the firms supplying these have been prepared and circulated.

8. *Sericulture.*—The experiments with crossing multi- and univoltine races of Mulberry Silkworms to procure a superior silk-producing multivoltine race have been continued but though many crosses were made, it has up to the present been impossible to produce a stable multivoltine race, although as mentioned last year some improvement has been obtained in the quality of the silk.

Univoltine European races were successfully reared on pruned tree mulberry, wild mulberry and bush mulberry and arrangements have been made to distribute eggs of these univoltine races for rearing in October. The difficulty with these eggs is that the temperature of the plains is too high to preserve them successfully during the dormant period and arrangements have been made to send the eggs to places in the hills where the temperature is not so extreme.

The Eri Silkworms were reared successfully throughout the year except in May and June, when, owing to the

extreme heat and dry conditions, the worms did not thrive and disease broke out in the cocoon stage, necessitating the rejection of the majority of the eggs obtained.

Numerous requests have been received for disease-free Eri and Mulberry Silkworm eggs, samples of cocoons, thread and cloth, pamphlets, castor seed and mulberry cuttings and seeds, and these have been complied with whenever possible.

Exhibits were sent to the Bankipore Exhibition and to the Exposition held in connection with the Anniversary of the Calcutta Scientific and Industrial Association. A demonstration of Eri and Mulberry Silk rearing, reeling, spinning, weaving, etc., was given at the Tirhut Agricultural Exhibition held this year at Pusa.

One drawback to the progress of the Eri Silk industry is still the difficulty which small rearers have of getting rid of the cocoons when they have obtained them, as the mills will only take large quantities for spinning.

9. *Lac-culture.*—The work of collecting and sorting the specimens of lac insects, received from the various Forest Range Officers, was continued. Experiments in lac culture were again carried out and two short courses on Lac cultivation were given, thirteen students receiving instruction. Numerous enquiries were received and answered regarding the cultivation, and brood-lac was supplied to a number of applicants. Inoculated *Ber* and *Kusumb* plants were also sent to Japan. An exhibit, showing the details of lac-culture, was sent to the Tirhut Exhibition held at Pusa and copies of a leaflet on the subject written in the vernacular were distributed.

10. *Apiculture.*—Two more colonies of American Italian bees were obtained from England in November 1911 and have proved very successful from the honey-gathering point of view, but so far, all attempts to obtain fertilized queens for multiplying the colonies have failed, apparently largely owing to the activities of certain bee-eating birds. The experiments will be continued, as it is important to determine whether it is possible to multiply the colonies in this country. Experiments have also been made with the

common Indian bee, *Apis indica*, and attempts have been made to accustom it to the modern bar-frame hive. These in a measure have proved successful, but progress is slow largely owing to suitable appliances not being available and more experiments are necessary before a definite opinion can be expressed. Several enquiries have been received with regard to apiculture and these have been answered as far as possible.

11. *Demonstration.*—The work of adding to the number of coloured plates of insect pests was continued and the new ones issued to the Provinces. A number of complete sets of coloured lantern slides were also issued. As mentioned previously, exhibits were sent to several Exhibitions.

12. *Insect Survey.*—Additions have been made to the general collections. Unnamed specimens of *Tettigidæ*, *Passalidæ*, *Cantharidæ*, *Rutelinæ* and *Psyllidæ* have been sent to specialists for identification and many of the collections sent out last year have been received back with the required information. Specimens have been identified for Provincial Assistants, the Indian Museum and many private collectors.

13. Programme of work for 1912-13.

As in previous years the work of investigating and advising upon insect pests will be continued. Assistance will be given, when desired, in co-ordinating the work of the Provincial Assistants and special help will be given in case of any serious outbreak. The preparation and issue of coloured plates and lantern slides will be proceeded with as before. The short courses in Lac cultivation and Eri and Mulberry silk-culture will be continued. Further experiments will be made with European and Indian bees. It is hoped that the collections of lac insects will be completed during the period. Eri silkworms will be reared and requests for help and advice will be complied with as far as practicable. The experimental work with Mulberry silkworms will be continued. New insecticides and apparatus sent in for trial will be tested and reported

upon. The field experiments with wheat and sugar-cane will be continued and further experiments have been commenced and will be carried on with a view to test the relative immunity of different varieties of cotton to the bollworm and also to extend the observations on the bollworm parasite.

14. Publicatons.

The following is a list of publications which have appeared during the period under review. As material accumulates, other Memoirs on the life-histories of insects will be prepared. Several Memoirs are now in preparation and include life-histories of *Orthoptera, Hemiptera, Lepidoptera* and *Coleoptera.* The revision of *Insects injurious to Indian Agriculture* is being proceeded with.

LIST OF PUBLICATIONS.

The Food of Birds in India. C. W. Mason, edited by H. Maxwell-Lefroy. January, 1912.

Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. May, 1912.

Life-histories of Indian Insects II. Some Aquatic Rhynchota and Coleoptera. D. Nowrojee. April, 1912.

Life-histories of Indian Insects III. The Rhinoceros Beetle (*Oryctes rhinoceros*) and the Red or Palm Weevil (*Rhynchophorus ferrugineus*). C. C. Ghosh. December, 1911.

Second Edition of Bulletin No. 23 on Insecticides, by H. Maxwell-Lefroy, revised with many additions, by T. Bainbrigge Fletcher. May, 1912.

Grasserie in Silk-worms. M. N. De. Agri. Journal, July, 1911.

Weevil and Dry Wheat. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

A Simple Honey-extractor. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Wax Moth. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Cabbage White Butterfly. T. Bainbrigge Fletcher. (Agri. Journal, January, 1912.)

Article on Litchi Mite. C. S. Misra. (Agri. Journal, July, 1912.)

Leaflet on the Bollworm in Cotton (*Gurumukhi*). October, 1911.

Cotton Bollworms in the United Provinces (Vernacular). C. S. Misra. January, 1912.

The following are in the Press:—

Memoir on Tetriginæ. Dr. J. L. Hancock.

Memoir on Life-histories of Hymenoptera. G. R. Dutt.

Memoir on the Big Brown Cricket. C. C. Ghosh.

Bulletin No. 28 on the Cultivation of Lac in the Plains of India. C. S. Misra.

Bulletin No. 29 on Eri Silk.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett, B.A., F.E.S.)

The programme for the past year has been considerably modified in consequence of the much closer relation with medical work which now exists. I am indebted to the Administrators of the Medical Research Fund for the addition of three posts to my staff, of which two have already been filled. These extra men will be engaged exclusively with "medical" entomology, and there will thus be at least two men available for Veterinary, Agricultural, and general work. The provision of these posts has rendered the question of accommodation more acute than ever, and a portion of the extra space required has been provided by the erection of a small supplementary laboratory now completed.

I have already put forward certain suggestions for the establishment of a medico-entomological laboratory for Northern India where entomologists and medical officers could work at any group of blood-sucking insects under the best conditions for obtaining material and observing the living insects in their natural habitat without undue risk to health. Such a laboratory should be in a district where blood-sucking insects attain their maximum abundance and variety: examples of such tracts are the lower slopes of the Himalayas and the Western Ghats and certain parts of Assam. It should be in some place having a climate sufficiently cool to allow of operations such as section-cutting to be carried on without inconvenience at any season, but should be on a railway or good road affording easy access to tracts where insects abound. The establishment of such a laboratory at some place fulfilling these conditions (*e.g.*, Shillong, the Kurseong neighbourhood, the Naini Tal road from Kathgodam, Igatpuri) would not necessarily entail any large expenditure if a site were available, and would

enable observations to be carried on with a facility unobtainable at any existing laboratory known to me, with the possible exception of Coonoor and Madras.

The work of the section has been largely concerned with mosquitos, and the life-histories of eighteen species of Pusa mosquitos have now been worked out. Special attention has been paid to the genus *Stegomyia* and allied forms, and a five weeks' course of instruction has been given to medical officers deputed to the "Stegomyia-survey" in connexion with the possible future importation of yellow fever. Seven officers attended the course. The most interesting point discovered regarding *Stegomyia* life-histories is that during cold and dry weather the two commoner species at Pusa (*S. scutellaris* and *S. thomsoni*) survive normally as dry eggs and not as active, hibernating, or æstivating adults. This has an important bearing on the practical question of checking the increase of *Stegomyia*.

Investigations have been begun on general mosquito bionomics, the main heads being the influence of temperature on mosquitos; methods of colouring or otherwise marking mosquitos in order to study their movements, and the range and rate of flight under natural conditions; sexual reactions of mosquitos; new larvicides; the food, feeding, and digestion of mosquito-larvæ; fish and other enemies of mosquito-larvæ. The difficult question of the breeding-places and habits of *Phlebotomus* has been taken up. A possible association with Termites may prove of importance.

Simulium-infested streams at Simla were examined with a view to finding methods of decreasing the numbers of the fly, but local conditions are such that no cheap method seems applicable. The life-history of the Crab-louse (*P. inguinalis*) was worked out (apparently for the first time), and its curious habits studied.

Other subjects which received attention are the parasites of *Tabanus albimedius* and of *Monophlebus stebbingi* var. *octocaudata*, the nature of the attraction of citronella oil for fruit flies of the genus *Dasyneura*, the life-history of *Celyphidæ* and improvements in mosquito-traps. The

East Indian Railway school at Jharipani was subjected to hydrocyanic acid fumigation on account of a plague of bugs, and the result appears to have been satisfactory.

As Secretary of the Entomological Sub-Committee appointed by the Malaria Conference in Bombay, I assisted in drawing up a scheme for organising work in pathological entomology.

A hand-book dealing with methods of drawing and reproducing illustrations for scientific papers has been passed for publication.

Programme of work for 1912-13.

The programme for the ensuing year will be subject to modification in accordance with any special requirements on the medical and veterinary side: Directors of Agriculture are being circularized in order that we may ascertain whether with respect to the latter there are any particular directions in which investigation is required. The special lines of work suggested by the Medical Department are mosquito bionomics and the breeding-habits of sandflies: both of these will be continued, and will in all probability form the major part of "medical" investigations; the former subject alone is one to which several years of work might be devoted. It is suggested that an appeal should be circulated throughout the country to enlist helpers and stimulate interest in medical entomology, and that specimens and information received should be dealt with either at Pusa or Kasauli; details of the arrangements are still under consideration, but at least some part of the work in this connexion would be done at Pusa.

Identification of specimens and any other work that may be required in connexion with the "Stegomyia-survey" will be undertaken, and more detailed observations of these mosquitos will be carried on. Experiments on methods of checking their increase have been begun at Pusa, and will continue until the onset of the cold weather.

An attempt will be made to elucidate the nature of the influence of citronella oil on fruit-flies: some unexpected

results were obtained in the course of the past summer, and a clearer understanding of the matter is desirable in view of the wide distribution of these flies and the serious damage they inflict in various countries.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I held charge of the section throughout the year.

1. *Charge and Establishment.*—The First Assistant Mr. N. V. Joshi was on privilege leave from October 9th to 23rd December 1911 and the Second Assistant Mr. K. S. Viswanatham was on privilege leave from April 9th to 29th June 1912.

All the Assistants in the section showed great interest in the work, and not only worked daily several hours overtime but made themselves sufficiently familiar with French and German to be able to read and make translations into English from papers published in these languages.

2. *Tours.—To Rangpur* to observe the conditions of incidence of bacterial disease of tobacco.

To Jorhat to see the manurial experiments carried out by Mr. Meggitt and the new Experiment Station of the Indian Tea Association.

To Dacca to consult Mr. Finlow on the subject of bacterial action in jute retting and "heart damage."

To Lyallpur to consult Mr. Barnes on the subject of "Reh" soils and to deliver a course of lectures on soil bacteriology.

3. *Soil Bacteriology.*—The work of the Bacteriological Section at Pusa during the year has been mainly directed towards ascertaining what factors determine biologic activity in Indian soils, and to the measurement of the changes resulting therefrom under various conditions. The main problem so far dealt with has been the supply of available nitrogen as provided by the biolysis of such substances as green manures, root residues, and organic manures. No work has been done upon nitrogen assimilation by Legume bacteria or such organisms as Azotobacter, Clostridium, or Rhizobium.

The method of determining the biologic activity of a soil by plate counts has been abandoned in favour of methods depending upon measurement of the physiological activity of the soil organisms. By the use of such methods biological analyses of soils may be carried out which will provide indications as to their relative capabilities for dealing successfully with organic manures. Far more valuable information, however, is also obtained by such analyses. By the use of fairly large portions of soil it is perfectly feasible to set up and maintain conditions of moisture and aëration comparable with those in the field, and to determine in the laboratory for any particular soil under what conditions of water supply, tillage, and addition of lime or manures, either natural or artificial, the greatest amount of ammonification and nitrification will result.

It has been ascertained by numerous experiments that the rate of formation of carbon dioxide in a soil is directly proportional to the biologic activity of that soil, and that conditions unfavourable to the latter will also adversely influence the former. A simple method of measuring the rate of formation of carbon dioxide in soils under various conditions has been devised and by this means it is possible to determine what moisture content of any particular soil is the optimum for bacterial activity; this has been found to vary from as high as 37 per cent. in one case to as low as 16 per cent. in another. By the same method the effect of the addition of various manures, organic or mineral, may be observed, and it has been found possible in this way to prescribe the addition of certain substances, such as lime or superphosphate, to a soil in order to promote the decomposition of green manures, oil-cake, or cattle manure buried in it. Similarly by determining the optimum moisture content, recommendations can be made as to variations in field practice which would tend to dry out the soil in one case or to conserve moisture in another; a very large number of observations have been made as to the conditions under which ammonification and nitrification take place in

Indian soils. It has been found that important differences exist between the biological changes taking place in the latter and those which have been observed in the soils of Europe; these differences appear to be due to the high average temperatures of Indian soils and their consequently high relative rate of bacterial action. In soil at temperatures between 15° C. and 18° C. the process of ammonification, which is the natural and necessary predecessor of nitrification, takes place at such a rate as to allow the latter to proceed *pari passu;* in many Indian soils, however, it has been found that at the higher temperatures 25° C. to 30° C. which obtain in them for many months in the year, ammonification may proceed with such rapidity as to produce a concentration of ammonia in the soil water sufficiently high to interfere with nitrification or even to inhibit it altogether. Where large quantities of nitrogenous organic matter are turned into the soil and put under intensive cultivation much nitrogen may be lost in the form of ammonia, and experiments have shown that the biolysis of organic nitrogenous material requires very careful investigation from this point of view.

It is evident that these facts must be taken into account in selecting the time of year for applying organic manures, along with other considerations depending on local meteorological conditions and the optimum moisture content of the soil.

Further experiments have demonstrated another source of loss of nitrate nitrogen. It has been shewn that where intense bacterial action is taking place in soil any nitrates present will be reduced without the occurrence of anærobic conditions; it appears probable that the nitrate is utilized as a source of nitrogen by the bacteria. It was found, for instance, that in Pusa soil the optimum moisture content for nitrification is 16 per cent. whereas general bacterial action is intense up to 25 per cent. and at the latter figure rapid reversion of nitrate to the protein form takes place. This would help to explain observations made in field practice both at Pusa and in the Punjab, that excess of soil

moisture produces nitrogen starvation of the wheat crop; the importance of biological analysis of irrigated soils by such methods will readily be realized.

A special enquiry has been carried on and is still proceeding, to determine the conditions under which bacteriotoxins are formed in soils and their effect in inhibiting bacterial action. The work of Greig Smith of N. S. Wales on this subject has demonstrated its importance, and experiments at Pusa have fully confirmed his views. Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, with whom I hope to collaborate on this subject, has carried out a series of investigations on similar lines, but the enquiry is not sufficiently complete for detailed report.

A complete series of experiments on green manuring was designed and commenced, in collaboration with the Imperial Agriculturist. This included observations in the field and in the laboratory as to the effect of varying treatment of the green crop (*Crotalaria juncea*) upon the condition of the soil and upon the succeeding crop. Field variations included burying after varying periods of growth, at different depths, and in conjunction with various artificial manures. Laboratory experiments were carried out to determine the rate and kind of change of the buried organic material under various conditions, with special reference to the formation of nitrate, and in order to obtain data which might help to elucidate the problems connected with the occasional failure of green manuring to improve soil conditions.

This enquiry will continue over two more seasons.

4. *Plant Pathology.*—A bacterial disease of tobacco at Rangpur was investigated and found to be due to an infection of *B. Solanacearum.* The strain isolated was found to be also pathogenic to *Solanum Melongena*, Tomato, Datura and Potato. The incidence of the disease at Rangpur and Burirhat was not apparently associated with any insect attack or specially unfavourable soil conditions, and was not heavy enough to cause apprehension as to future spread. The parasitism of the causative organism as

isolated from diseased plants in the field was found to be insufficiently strong to attack healthy plants, although by passage through several individuals or by artificial culture on Potato it could be raised to a high degree of virulence. For this reason the practice of leaving the plants in the ground for a second cutting should be avoided in infected areas.

A bacterial disease of wheat in the Punjab, locally known as "Tannan" or "Tandu," was investigated; this was found to be due to the attack of a bacillus closely resembling *Ps. Hyacinthi* which invests the opening ear with a sticky growth causing deformation and stunting and preventing ripening of the grain. The attack is confined to small badly drained areas and can probably be avoided by proper cultivation; its distribution is limited and it is probably of no economic importance.

5. Programme of work for 1912-13.

Work on influence of soil conditions upon nitrification will be continued.

A new line of enquiry will be commenced this year with the object of determining the conditions under which nitrogen fixation by so-called non-symbiotic organisms may balance losses of nitrogen due to various causes under agricultural conditions.

The green manuring experiments will be continued in collaboration with the Imperial Agriculturist.

Should time permit an attempt will be made to obtain more precise data as to the effect of variations in temperature, moisture, and aëration upon nitrification in soils with special reference to field conditions and agricultural practice. The apparent inhibitory action of various crops will be taken into account, and the effect of different systems of cultivation upon aëration and moisture content of soil.

Work on formation of soil toxins and their influence upon bacterial action will be continued. It is hoped that this may be done in collaboration with Mr. Meggitt.

Experimental work on the "Ufra" disease of Paddy with reference to soil conditions will be continued.

Indigo wilt.—This will be investigated with a view to the possibility of its bacterial origin.

Training of students will be continued.

6. List of Publications.

Hutchinson, C. M.—Studies in Bacteriological Analysis of Indian Soils—No. 1, 1910-11 (Mem. Dept. of Agriculture in India, Bacteriological Series, Vol. I, No. 1).

ANNUAL REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I held charge of the appointment throughout the year. The first two months were devoted to the establishment of the series of experiments on which I had decided to work out the manurial requirements of the cotton plant in India and the differences which may perhaps accrue from the presence of various manurial ingredients in the soil. This enquiry will only give data for estimating results in the course of a few years.

In September and the early part of October I visited the Mysore State to suggest some preliminary lines of experiments. The greater part of October was devoted to a tour in the Punjab and the United Provinces.

In November I visited Berar and then attended the Conference of the Agricultural Board at Pusa where I had opportunities of discussing cotton work with members of all the Agricultural Departments in India.

In January I visited Assam to advise a planting firm regarding the cultivation of cotton in that Province.

During the intervals throughout the year I was engaged in supervising my own experiments and in advising, with some degree of detail, more than twelve correspondents in India and other parts of the East, on special points connected with the cultivation of cotton.

To further my botanical researches I obtained seeds of the indigenous cottons in the Kashmir State and the varieties of wild cottons existing in Sind.

A number of cotton samples were exhibited and explained at the Mysore Industrial Exhibition. For these the committee awarded a diploma and the notes accompanying the exhibits were considered sufficiently useful to be quoted in full in the Exhibition catalogue. A set of cottons were sent for exhibition in the North-West Frontier

Province, by Mr. Robertson Brown, who considered that the quality of the samples would help the cultivators to realise how cotton should be turned out for the market.

To simplify this Report for purposes of reference I give the information I have gathered from each Province separately.

The Central Provinces and Berar.—Mr. Low, the Director of Agriculture, at the general meeting of Agricultural Associations at Akola, in November, ably summarised the present condition of cotton cultivation in his Province and, as this paper was presumably only for the information of members and visitors and will probably never attain general circulation, I take the liberty of transcribing such portions as pertain to my subject. Having been honoured by being allowed to follow closely the work done in the Province, since its initiation, I can vouch for the accuracy of the details, and the importance of the subject requires no apology for its introduction.

The centre of cotton work is at the Akola Experimental Station, which was opened six years ago. Great care was taken to select uniform areas for the different series of experiments. This was done by growing *juar* over the whole area to start with and by selecting areas of uniform fertility as ascertained by experimental weighings. Where the land was found to be uneven in fertility, as proved by variations in the outturns, it was discarded as being unsuited for experimental purposes.

From the experiments, which have now been going on for five years, several very practical lessons have already been learnt. These are being carried into practice in the non-experimental areas and are also being recommended for adoption by other cotton growers. It has been proved that the turn wrest plough is an excellent implement for eradicating weeds and for deep and thorough cultivation generally; that the Hoshangabad iron tined *bakhar* is a very useful implement for uprooting cotton stalks in the field before preparing the land for the next year's crop; that the Akola hoe is a better implement than the Berar *doura* for

interculture as it produces a deeper tilth in the black cotton soil. Turn wrest ploughs will, in future, be made in India by Messrs. Burn & Co., Calcutta, and agents have arranged to stock them at the various cotton centres.

Much attention is being paid to experiments with the different manures on this farm and the excellent crops that clothe the fields are largely the result of high manuring.

Most cultivators in this Division grudge to pay even 12 annas for a cart-load of cattle dung; its manurial value for cotton is at least twice that. The cultivator who neglects to manure his land is a loser because by withholding one small item of expenditure, namely, manure, he lessens very considerably the effectiveness of the other items, *viz.*, cost of cultivation, seed and supervision. Increased outturns have been obtained on the farm from the use of cattle dung, poudrette and saltpetre as manures for cotton and *juar*. The most economical of these is poudrette which is obtainable in fairly large quantities from all the large towns in Berar. A source of manure which is neglected all over India at present is cattle urine when conserved by the dry earth system. It has been proved at Akola that, for cotton and *juar*, the manurial value of a farm animal's urine is equal to that of its dung and by conserving the liquid manure, the value of the manure available on a farm can be doubled.

Nitrogenous fertilizers, such as nitrate of soda and saltpetre, when used as a top-dressing after the application of cattle dung, have also given very good results. It will pay to use them as a manure for cotton to supplement the inadequate supply of cattle dung so long as the price of that staple remains high.

The quantity of lint yielded by each variety varies from $36\frac{3}{4}$ seers per acre for *bani* to $80\frac{1}{2}$ seers for *rosea*. As the value of a cotton depends very largely on the quantity of lint which it gives, *rosea* stands easily first and *bani* is distinctly the poorest yielder. The advantage to be gained by growing *rosea* in preference to Berar *jari* is that it gives

more *kapas* and a higher percentage of lint. A profit of about Rs. $11\frac{1}{2}$ per acre is made on this farm by growing *rosea* instead of Berar *jari*. *Malvensis* also does well in certain localities and the lint is much superior to that of *rosea*, but it is a less profitable variety to grow owing to the lower percentage of lint which it yields.

Vera closely resembles *malvensis* and *cutchica* somewhat resembles *rosea*.

Bani or *Hinganghat kapas* is, from the point of view of quality, one of the best cottons grown in India, but it gives less than half as much lint as *rosea* and buyers are not willing to pay more than from 20 to 30 per cent. more for its lint than for that of *rosea*. Consequently it is hopeless to expect that it can be grown as profitably as *rosea*. The only chance of improving it with effect seems to be to raise the ginning percentage. The strain, evolved by selection on the farm gives 3 per cent. more lint than ordinary *bani*.

Bhuri is the best exotic cotton yet tried in the Province. It is entirely resistant to wilt which is now doing considerable damage to Berar *jari* in certain parts of the Division. *Bhuri* is recommended for such areas and for the rich *khari* lands of the villages. It suffers more from drought than Berar *jari* but less from excessive rain. Before this farm was opened the terms *rosea*, *malvensis*, *cutchica*, etc., were quite unknown, but now these are household words in Berar and many cultivators are growing these varieties pure for seed distribution.

Rosea is being grown on 31 seed farms in this Division; *malvensis* and *cutchica* on 4, *bhuri* on 33, and it is reckoned that there are 5,000 acres under this new variety in Berar alone this season. It is gratifying to note that all this has been accomplished by the Department of Agriculture, mainly through the agency of the Akola Farm, within the short space of five years, and that these different varieties had never been grown pure previous to that time. Several cultural points have also been decided, such as that topping

cotton reduces the yield, that the best spacing distance for Berar *jari* is 15 inches apart for the rows and 7 inches apart for the plants in the rows, that cotton sown before the monsoon breaks gets a good start and gives a larger yield than that sown after the rains have set in, if the blanks are dibbled in.

Mr. Clouston adds that cotton grown continuously in the same field for a period of years has become a fairly common practice in Berar. This disregard of the principle of rotation in cropping is decried by scientists, who attribute to it the spread of insect pests and fungoid diseases. The results, up to date, however, have not justified that assumption. The experiment has now gone on for four years; no trace of disease and no serious damage by insects have yet been noticed. Economically the practice has proved a sound one owing to the high price of cotton and it is, therefore, being followed in the non-experimental area of the farm.

Finally, the increasing demand for pure *rosea* seed has been very marked. The Department admit that, in this part of India, *bhuri* cannot be grown at as large a profit as *rosea*, except in wilt-infested, wet or *khari* areas. Cambodia cotton gives a poor return. It is more than a month later than the indigenous varieties and suffers from the early cessation of the rains in Berar.

In my last year's report I explained the good work that is being done at the Khandwa Agricultural Station by Mr. G. Evans, the Deputy Director of Agriculture, Northern Division, Central Provinces. This year he has furnished samples of five sorts of cottons grown at the same station and of two samples which he has picked out during his researches throughout his District. One is from Chhapara, a high plateau in the Seoni District of the Satpura, and the other from Patan in a part of the Jubbulpore District which is liable to early frost. He considers from the geographical situation of both tracts that an early ripening variety is absolutely essential. From the valuations it

is evident that these tracts already possess a fairly valuable cotton.

Messrs. Tata, Sons & Co. have kindly furnished me with the following valuations and remarks on all the above-mentioned seven samples :—

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the seven samples of cotton from Khandwa, on 20th February 1912.

Serial No.	Name of sample.	Remarks.
1	*Bhuri*	Compared with local cotton of Khandwa this cotton is far and away superior. It is soft and silky in feel and has a fine long fibre. It is more like the Bassim cotton of the tableland. Taking Akola as our basis for valuation at Rs. 275 we value this cotton 15 rupees higher, say Rs. 290.
2	*Malvensis* . . .	Same style of cotton as No. 1, but the length of the fibre is slightly shorter though the staple shows more strength. Same value as above, *viz.*, Rs. 290 per candy.
3	*Cotton from Chhapara* .	Bengal style of cotton, but of superior quality for which we value it 10 rupees higher than Fine Bengal, *viz.*, Rs. 280 per candy (Bengal Fine Rs. 270).
4	*Saugor jari* . . .	Same style as No. 6, but a shade better and more even in staple. Value Rs. 275.
5	*Local*	Same as No. 4. Value Rs. 275.
6	*Roseum* . . .	This cotton is equal to local Khandwa cotton and shows no improvement. Value same as for local Khandwa cotton, *i.e.*, Rs. 270 per candy.
7	*Patan*	Punjab style of cotton. Compared with No. 3 it is inferior in colour but a shade better in staple. It is more like fine Mooltan cotton. Value Rs. 265.

Punjab.—I visited the Punjab in October and completed a joint inspection of the cottons of that Province, with Mr. Milne, the Economic Botanist.

There are two varieties of the dark flowered and broad lobed *G. sanguineum*, one with dark, the other with green

stems. Great variations in staple are found in these plants. Selection experiments have proceeded probably as far as they can be taken and the staple obtained attains the length of ·8 inch. It has been proved that the shortest staple is associated with the hardiest and darkest coloured plants. Excepting the characteristic of coloration which is a negligible factor in other parts of India, the above fact is a further confirmation of our experience that hardiness and poor staple are companion characters.

The variety which I have already published under the name of *G. obtusifolium* var. *hirsutior* seemed to be unsuited for cultivation owing to its prolonged season of growth, but it may yet prove useful in cross-breeding.

The remaining indigenous forms of Punjab cottons are yellow and white flowered forms of *neglectum* and *indicum*, all, however, with a strong tendency to show true *neglectum* characters.

Khaki hirsutum is unsatisfactory from its producing cotton of varying tints and many bolls bear quite white cotton. A good, even, white colour is a desideratum in a cotton produced for sale in the Indian market and buyers are prejudiced against coloured cottons.

Of the indigenous types the broad lobed *sanguineums* are by far the most promising and it would be well to draw the attention of the cultivators to these as they are of a particularly desirable type. The outturns of all the plots appear to be excellent.

The Upland cottons were described to me by an American expert as being the best he had seen outside the United States.

Two varieties come into bearing as early as the indigenous cottons, but it is still to be seen whether they are quite early enough to save one watering or not and this is a matter of important consideration to the zemindar. The successful introduction of these cottons into more general

cultivation will, of course, depend on the willingness of the selected zemindars to devote more careful attention to cultural methods than they at present exercise in the case of their *deshi* cottons. The valuations received on these cottons show, by a comparison of outturns, that the most highly priced varieties are by no means the most profitable to grow.

Mr. Conville, a local cotton merchant, mentioned that during this year he had observed a great improvement in the cultivation of cotton in the Colony and he attributed this advance to the good example held out by the Lyallpur Farm. He considers that the bad practices of cotton sellers and buyers, ginneries, etc., have helped to lower the prestige of Indian cottons.

Mr. Miliades says that in his long experience of Lyallpur, the yield of cotton has fallen from 10 to 12 maunds to 4 or 5 maunds per acre. He thinks that this decrease is wholly caused by the diminishing fertility of the soil which was practically virgin land only a few years ago. Mr. Milne explained to me that the natural indigenous vegetation of the tract before the days of irrigation consisted mainly of leguminous plants and that the cotton yielded its maximum while the plants could draw on the nitrogen stored in the soil. His idea of introducing Berseem or Egyptian clover as a fodder and a renovator of the soil is a sound one and I shall follow with interest the results of his experiments. The deterioration of some well-known staples in the Punjab is said to be due to careless cultivation and treatment. Multan cotton (a pure *sanguineum*) is a hardy cotton capable of producing full crops on the western side of the Province. Mr. Miliades considers that even now, in many respects, he prefers this cotton to the *Narma* or acclimatized Upland cotton.

Mr. Roberts is growing on a field scale what has been handed over to him by the Economic Botanist and he already has urgent demands for select seed from the cultivators. This is, in itself, sound proof that the cultivators realize the value of what is being done for them. The

maintenance of pure types in their hands, however, is the most difficult problem confronting the Department and it is impossible to foresee at present how it can be solved. A due appreciation of the difficulties of this task leads us to the conclusion that, although a number of varieties can be safely tried on a small scale, for distribution purposes it would repay the Department to work with one *deshi* and one American only. Afterwards when it is known that special tracts require their own special varieties, then the safest course to pursue would be to establish seed farms on these areas. This has been already successfully accomplished in the Central Provinces.

Messrs. Tata & Sons of Bombay have courteously given me a report on Punjab cottons drawn up by one of their agents who was buying Upland cottons. The following is the gist of it: "The *deshi* and American cotton grown in the Lyallpur District have been deteriorated by boll weevil and frost and in some parts large tracts of cotton fields have been totally destroyed. The total crop in this district would be about 10,000 to 11,000 bales, whereas last year it was about 35,000 bales. The general complaints about the *kapas* this year are large percentage of unripe *kapas*, yellow stains from boll weevil and short staple. These tend to give decreased outturn and dull colour. The cultivation of American cotton is not yet universally taken up in the whole district. It is chiefly grown on the horse-breeding farms, called Risala, the Agricultural Farm and by a few private farmers. The crop of Risala No. 15 is the best in the district this season. The seed was obtained from the Agricultural Farm, which obtained it from Dharwar some years ago. On the whole the quality of this cotton is good except that no care seems to have been taken in picking. The fibres are strong and pliable and the regularity in their length would enable good yarn up to 24^s to 40^s to be made in warp and weft. I am sorry I am not able to make the same remarks on other American cottons grown in the district.

"I have seen several samples of American cotton grown by farmers and have not seen any equal to that of No. 15 Risala. Generally there is an apathy to cultivate American cotton as it gives less percentage of lint and requires more care than *deshi kapas*. The Agricultural Farm is striving hard to select such American seed as would suit the climate and give a large percentage of lint and long stapled cotton. During the short time of its existence it has distributed various sorts of American seeds among the farmers and hence the trouble, as many of the American varieties are not suitable to the climate. The farmer also gives the American the same treatment as his *deshi* sorts. As the fibre of the American cotton is very thin and fine, special care is essential in picking and handling. The method of storing the *kapas* is also very defective, and this defect is not only found among the uneducated farmers as I was surprised to see the *kapas* of the Agricultural Farm stored in large, iron cisterns about 15 to 20 feet high. The stuff was not loosely packed but it was pressed hard, a procedure which is sure to spoil the staple and colour and increase the waste in the blow-room. If a proper method is pursued throughout there is a splendid future for American cotton in this district. The soil is rich and, from the farmer's point of view, the soil that gives good wheat can also yield a good cotton crop. It may be that the improvement cannot be achieved in a few years, but the picking can be improved now, if more care be taken. To make the American cotton grown in India commercially successful it is very essential indeed that particular care should be taken in picking. I send you two samples of cotton, both from the same farm (No. 15 Risala) and from the same seed. The only difference between them is that the former was carefully picked and such a sample can be commercially classed as F. G. M.; the latter, though equal in staple and regularity, can be classed between L. M. and Med."

In a further communication Messrs. Tata, Sons & Co. have given me the results of the working of Lyallpur cotton, compared with American, *bani* and *bhuri* types. The

count spun was 24^s and in all cases the number of turns per inch was the same.

	Loss per cent. on cotton in blow-room.	Tension of 24^s warp.
American F. G. M. Boweds . .	7·75	57·44 lbs.
Panderkora Bani	·34	60·33 „
Lyallpur	10·08	52·20 „
Bhuri	10·37	46·10 „

The prices at the time of purchase of these respective varieties were very nearly the same in all cases, being about Rs. 130 per *boja* of 345 lbs. laid down at Nagpur.

On this basis, but including the blow-room loss, the purchase prices per lb. work out as follows :—

American	6·5	annas	per lb.
Panderkora Bani . . .	6·53	„	„ „
Lyallpur	6·63	„	„ „
Bhuri	6·65	„	„ „

To conclude with the Punjab, it is necessary to add that Messrs. Tata, Sons & Co. and the Directors of the Bombay Cotton Trade Association have thus remarked on a set of samples submitted to them for opinion by the Economic Botanist : " Only two samples out of the 27, Nos. 161 and 179, can be compared with American. They are splendid cottons, especially in the length and strength of their fibres, and every help and encouragement should be given for their cultivation on an extensive scale. If the cultivation of these cottons turn out a commercial success it will finally solve the problem of obtaining long staple cotton from the British territory. We are afraid, however, that the dream is difficult of realization. The exotic has to contend with the soil and climate as well as with the apathy, indifference, ignorance and prejudice of the Indian cultivator."

The valuations of these samples in order of merit, by the Bombay Chamber of Commerce and Messrs. Tata, Sons & Co., Bombay, are appended. As the outturn and percentage figures are unknown to me it is impossible to say in the absence of these data which if any of them are the most

profitable to grow, and I hope that the Department in the Punjab will be able to furnish the figures necessary for comparison.

Valuation by the Bombay Chamber of Commerce.

BASIS.

Middling American at Rs. 340 per candy of 784 lbs. less 5½ per cent.
Fine M. G. Naosari „ 320 „ „ „ „ „
Good Tinnevelly „ 310 „ „ „ „ „
Fine M. G. Broach „ 290 „ „ „ „ „
All for ready delivery in Bombay.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	REMARKS.
		Rs.	
1	161	425—450 (Nominal).	Superfine long silky staple. Impossible to give accurate valuation and sample should be sent to Liverpool.
2	280F	380 (Nominal).	Strict fine, long staple and good colour.
3	271	365 (Nominal).	Superfine, good long staple, good colour.
4	274	350 (Nominal).	Strict fine, long silky staple, good colour.
5	246	325	Superfine, long silky staple, good colour.
6	272	320	Strict fine, nice staple and colour.
7	273	320	Fine, rather better staple than 272.
8	72F	320	Superfine in class, long silky staple, good colour.
9	111	320	Strict fine, good staple and colour.
10	168	315	Strict fine, good strong staple.
11	112	312	Strict fine, good strong staple and colour.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	Remarks.
		Rs.	
12	126	310	Superfine class, strong staple, good colour.
13	199	310	Superfine, strong staple but not very long, good colour.
14	7F	305	Strict fine in class, nice staple but not very silky, good colour.
15	110	300	Strict fine, good staple, and good colour.
16	267	300	Superfine, staple a little better than 266. Cotton is more bulky.
17	275	300	Strict fine, moderate staple, good colour but leafy.
18	70F	295	Strict fine in class, irregular and rather rough staple, good colour.
19	276	295	Fine, moderate staple, leafy.
20	220	290	About fine, staple strong but rather rough and irregular.
21	266	290	Strict fine, only moderate staple, nice colour.
22	233	280	Strict fine, fair staple but rather rough.
23	270	280	Fine fair staple.
24	226	275	Superfine, rough and short in staple, more like Rajputana cotton.
25	232	270	Fine, rather rough and short in staple, colour not so good as 226.
26	28D	265	Strict fine, poor staple and very wasty.
27	179	..	No sample sent.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Remarks.
1	179	Quite equal to Fully Good Middling American cotton. To-day's (10th July) price will be 8*d.* per lb.c. i. f. Bombay or say Rs. 425 per candy.
2	161	This cotton is far and away the best of its kind grown in Indian soil and acclimatized to the Indian climates. Though not exactly after the American style, it is no way inferior to Good Middling. The length of the fibre is fully 1⅛ inch. Good Middling American of 1⅛ inch staple cannot be laid down in Bombay under 7½*d.* per lb. or say Rs. 365 per candy. If you add 5½ per cent. discount allowed in Bombay the cost comes to Rs. 385 per candy. We value this cotton, therefore, at Rs. 385 per candy.
3	271	This cotton is exactly like Naosari in its feel and length of fibre. Value Rs. 340 per candy.
4	274	Equal to the very best Surat. Value Rs. 325 per candy.
5	72F	This has the characteristic and style of the best Surat and being slightly better than 7F in the length of fibre, we value it Rs. 5 more, *viz.*, Rs. 325 per candy.
6	7F	This cotton is of the Surat style. It has a long even fibre like Surat, and the colour and appearance are strikingly like it. It is lacking, however, in the soft silky feel of Surat cotton. We value it in price equal to the best Surat cotton namely, Rs. 320 per candy.
7	111	This is again the best Surat style of cotton equal to 7F. Value Rs. 320 per candy.
8	68	Best Surat style of cotton. Value Rs. 320 per candy.
9	246	Surat style of cotton. Value Rs. 320 per candy.
10	272	Surat style of cotton. Value Rs. 320 per candy.
11	112	It is same as 111, but a shade short in the length of fibre ; therefore, we value it Rs. 5 less, say Rs. 315 per candy.
12	270	Surat style of cotton, but slightly shorter in fibre. Value Rs. 310 per candy.
13	273	Surat style of cotton, but slightly inferior in staple. Value Rs. 310 per candy.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Remarks.
14	276	Broach style of cotton, but a little longer in fibre even than 275. Value Rs. 305 per candy.
15	275	Broach style of cotton, but being slightly longer in fibre than Broach, we value it at Rs. 300 per candy.
16	267	Same as 266 but slightly better in staple. Value Rs. 300 per candy.
17	126	It is midway between the best Broach and Surat. It approximates more to Broach and we value it Rs. 10 more than fine Broach, *viz.*, Rs. 295 per candy.
18	266	Equal to the best Broach cotton. Value Rs. 295 per candy.
19	199	Best Broach style of cotton. Value Rs. 290 per candy.
20	220	This cotton has the style of superior cottons of the Central Provinces, say Warora and Hinganghat. Value Rs. 290 per candy.
21	70F	This cotton has the appearance of the best Broach and the fibre is a shade longer than that of Broach. We value it, therefore, at Rs. 290 per candy, say Rs. 5 more than the price of Broach.
22	110	This cotton resembles the superior grade cottons such as Warora and Hinganghat grown in the Central Provinces. It is slightly dull in colour; therefore, we value it Rs. 5 lower than Warora, *viz.*, Rs. 285 per candy.
23	226	This is of the style of inferior cottons of the Central Provinces, such as Wardha and Nagpur. Value Rs. 285 per candy.
24	233	Wardha or Nagpur style of cotton of the Central Provinces. Value Rs. 285 per candy.
25	232	Best Berars style of cotton such as Yeotmal. Value Rs. 280 per candy.
26	28D	In colour and style like superior Berars, but the fibre is very short and weak; therefore, we value it at Rs. 275 per candy.
27	280F	No sample sent.

Prices fixed upon the following *basis*:—

Bombay candy weighs 784 lbs. The price of cotton in Bombay includes a rebate of 5½ per cent. For example if you purchase cotton, say, at Rs. 300 per candy, the seller allows you a rebate of 5½ per cent. so that the actual price of cotton is Rs. 283½ per candy. Therefore, the prices quoted are subject to a rebate of 5½ per cent.	American Good Middling . .	7½*d.* c. i. f.		
	„ „ „ . .	Rs. 365	net per candy.	
	Fine Naosari	340	per candy.	
	„ Surat	320	„	„
	„ Broach	285	„	„
	„ Warora-Hinganghat (Central Provinces).	290	„	„
	„ Wardha (Central Provinces)	285	„	„
	„ Yeotmal (Berars) .	280	„	„
	Good Tinnevelly . . .	320	„	„

United Provinces.—I visited these in October and toured in the company of Dr. A. E. Parr, the Deputy Director of the Northern Division.

I made the following notes on my inspection of the cottons on the Agricultural Experimental Station at Aligarh :—

(1) *Bhuri* (*G. hirsutum, variety*, originally from Chota-Nagpur). This has grown well, but the yield is low and last year it produced practically no crop. I pointed out to Dr. Parr that the species normally consists of a mixture of a productive and non-productive form, the latter predominating in his plots. If selection is continued by using the former type, he will soon possess a strain of high class cotton suitable for his Division in all respects.

(2) Mr. Leake's selection (white flowered cotton or *G. roseum*) yields well and is a moderately early cotton.

(3) Mr. Leake's selection (broad lobed white flowered cotton, var. *cutchica*) has produced at the rate of 12 maunds of seed cotton per acre and on the score of outturn alone is distinctly promising.

(4) *Kil* or Garo Hill cotton is more productive than the two last named, but our experience is that it deteriorates rapidly to the standard of local types.

(5) Yellow flowered *Neglectum*. This yields a cotton of better staple.

All the field experiments are on the white flowered or *Varhadi* type of cotton. As in other parts of India, owing to its hardiness, high produce and also high percentage of cotton to seed, it is rapidly becoming the favourite variety of the cultivators. Already Dr. Parr has 300 acres under this in seed farms and next year he hopes to increase their area to 3,000 acres. In price of crop it surpasses yellow flowered cotton by Rs. 12 to Rs. 15 per acre. There is little difference in the yield of broad cast and drilled plants. The best spacing distance has been found to be 18 inches between rows and 9 inches in the rows. A yield of 10 maunds of seed cotton per acre has been obtained. White flowered cotton grown with ground-nut yields about half the ordinary unmixed crop. The general practice is to grow cotton with *Cajanus indicus*. Dr. Parr says that in the Aligarh District about half the cotton crop is irrigated. Southwards the proportion of irrigated cotton decreases.

Mr. Graham, the Manager of West's Patent Press at Aligarh, thinks that, so far as cotton improvement is concerned, it would be sufficient to increase the outturn. He also thinks that a better staple should be arrived at. Few traders I have met seem to appreciate the fact that an increased staple in *Bengals* is invariably accompanied by a falling off in yield and percentage of cotton to seed.

After a discussion with Dr. Parr regarding his future line of work we agreed that the following would be most practicable :—

(1) To purify out the white flowered cottons and extend their cultivation as pure types. They have already been tested and proved to be more pro-

ductive and remunerative than the yellow flowered types.

(2) For the present we must conclude that American cotton has had a fair trial and has failed. In some cases it yielded badly and in others it could not meet with a suitable market.

(3) Dr. Parr will continue his experiments with the form of *Bhuri* that I have pointed out to him as being most suitable for the purpose.

(4) The experiments with yellow flowered *neglectums* should be persevered with. The staple is superior and it may prove remunerative to produce the cotton as a pure type. I showed Dr. Parr in the field how to readily distinguish the most productive plants of both white and yellow flowered cottons.

In company with Dr. Parr I visited Kashipur where a particular class of cotton was said to be grown. We found that the cotton was of exceptionally good quality, approaching in appearance and staple, the *Bani* or *Hinganghat*. I have advised Dr. Parr to make all his selections in the tract and not risk damaging the reputation of the local produce by bringing in anything from outside. I have since seen it mentioned in the newspapers that the Department is establishing a seed farm here.

The Tahsildar of Kashipur, Mr. Thakar Raghunathsingh, gave the following information. The rainfall of this tract averages between 40 and 50 inches. Last year it was 64 and this year 36. Last year the acreage under cotton was about 5,000 and this year 4,500. Wild animals from the reserved forests damage all crops excepting cotton. The average yield of seed cotton is 9 maunds per acre and under the most favourable conditions it reaches 12 maunds.

The price of Kashipur cotton is Rs. 2 per maund higher than that of ordinary *Bengals*.

The ginning factory proprietor at Kashipur is extremely anxious that no rough sort should be introduced to spoil the quality of the local fine variety.

I learnt that there are large areas of land suitable for cotton in Kashipur, especially near the reserved forest where the ravages of wild animals render the cultivation of grain crops so uncertain that these parts are relapsing into jungle. The quality of this cotton seems to be so excellent that (as I have already emphasized) all selection should be worked out on the spot and nothing in the way of *deshi* cottons should be introduced, whether they seem superior or not. There is a grand field here ready for growing selected local cottons and I am certain that Dr. Parr will not be slow in developing the possibilities of this tract. That two ginning factories have already been erected on the spot is proof positive of their owner's anticipation that the cultivation of cotton in this favoured tract will ultimately extend largely and rapidly. Personally, I was gratified to discover this tract as I was by then despairing of finding anything in the United Provinces better than ordinary *Bengals*.

The cotton grown round Chandausi is famed for its whiteness and staple. It is grown as a dry crop and sold at a higher price than ordinary *Bengals*.

There is only one variety or type of this known and it is decidedly inferior to Kashipur cotton.

Messrs. Ralli Brothers' agent here informed me that in a good year Chandausi cotton can be classed as Oomras, but that it is very inferior this year. He also considers that on the whole the United Provinces' cottons are inferior to those of Berar. The poorest qualities come from the westward (Beawar for example) and there is a gradual improvement to the eastward.

The United Provinces' cottons consist of the usual mixture of the types yielding *Bengals*, and at Aligarh Farm it can be seen that these types are easily separated.

It is to be regretted that the cultivation of American cottons has failed, but the Department should remember that there is an expressed demand for improved indigenous cottons from traders and manufacturers in the Province itself, which it should attempt to satisfy.

The following are the valuations kindly furnished by Messrs. Tata, Sons & Co., Bombay, on the 5 samples grown at the Agricultural Station, Aligarh, last year :—

Valuation of the samples from Aligarh Agricultural Station (valued on 18th January 1912).

Out of 5 samples, Nos. 1 to 5, sample No. 2 is the best of the lot in point of length of fibre and feel. We value it to-day at Rs. 265 per Bombay candy, or say Rs. 15 more than the price of Fine Bengal (F. Bengal Rs. 245).

No. 3 is slightly inferior to the above in length of staple, value Rs. 260.

Nos. 1, 4 and 5 are all alike and may be valued at Rs. 255.

The above cotton is harsh in feel like wool and resembles Assam cotton. It can be used in mixing with wool as Assam is on the continent, hence it has a special value of its own. This kind of cotton is generally 15 to 20 rupees higher in price than fine Bengal in normal times. We value Assam cotton to-day at Rs. 265 per Bombay candy.

Madras.—I have had no opportunity of visiting this Province during the year, but a letter from Mr. Couchman, Director of Agriculture, to the Board of Revenue, last year, fully explains the situation. From this it appears that in Tinnevelly, the *Karunganni* variety of cotton and in Nandyal the white seeded *Tellapathi* cotton have been proved by field experiments, supported by expert opinion from the mills, to be superior to the mixed field crops of cottons ordinarily grown in the Tinnevelly and Kurnool Districts. To extend the cultivation of these varieties seed farms were opened in Tinnevelly in 1908 to grow *Karunganni* on a large scale. In Kurnool a beginning was made last year with 35 acres of seed farm for growing pure *Tellapathi* seed.

The rapid increase of the area under *Karunganni* showed that the people were keeping the seed themselves. With a view, therefore, to extend the variety to new tracts, 43 seed depôts were opened, many of them in new tracts,

as the tracts in which some of the depôts were opened in previous years had now become pure *Karunganni* tracts.

Very gratifying evidence is now forthcoming to show the value of this crop to the cotton trade of the district. In two cases, new ginning factories have been opened by export firms, in localities where pure *Karunganni* has been introduced on account of the fine quality of cotton now obtainable there.

The large distribution of seed by the Department has made the Tuticorin Circle practically a pure *Karunganni* tract. Messrs. Volkart Brothers write :—"We have during the last few years noticed that a relatively very good cotton is received from places near Koilpatti, including the railway stations of Nalaturputtur, Kumarapuram and Kadambar. We have no hesitation in concluding that your experiment has been highly satisfactory in its results. The cotton from these places fetches a better price and is better liked by spinners both in Europe and the East than the bulk of Tinnevellies which are marketed further north at Virudupatti, etc."

Messrs. Ralli Brothers also state that there has been a marked improvement in the quality of Tinnevelly cotton during the last few years, especially in the Tuticorin Circle.

This independent evidence from the large buyers is most encouraging as it shows that an appreciable improvement can be effected in a short time to the whole crop of the tract by the methods worked out by the Department.

In the Northern Circle there was a keen demand for the farm seed which gives better crops than the seed available from the usual sources.

There is also a large demand for Cambodia seed, but this season there is a disquieting report to the effect that it has deteriorated in staple so that manufacturers cannot spin the usual counts from it. An enquiry into this matter has already been instituted.

Valuation of the 17 samples of cotton from Koilpatti (Madras) furnished by the Bombay Chamber of Commerce, on the 18th April 1912.

Serial No. (according to merit).	Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	Remarks.
	Uppam Variety.	Local value.	Export value.	
		Rs.	Rs.	
1	Uppam—Ordinary field crop . .	283	283	These samples are all disappointing in so much as the staple is harsh and rather like Rajputana cotton (Bengals).
2	Pedigree Uppam	280	280	
3	Do.	280	280	
4	Uppam—Ordinary farm crop . .	280	280	Staple very harsh and short.
5	Pedigree Uppam . . .	275	275	Same remark as for Nos. 1, 2 and 3.
	Karunganni Variety.			
1	Pedigree Karunganni . . .	335	Export value nominal.	Nice style with long silky staple.
2	Do. do. . . .	335		Long silky staple and very good spinning cotton.
3	Do. do. . . .	330		Nice staple, good style.
4	Karunganni—Ordinary field crop .	330		Very good staple.
5	Do. do. .	325		Very good staple.
6	Pedigree Karunganni . . .	325		Long staple and good style.
7	Karunganni—Ordinary farm crop .	320		Good staple.
8	Do. Ordinary field crop .	315		Good staple.
9	Do. do. .	310		Very bright clean cotton, but staple not nearly as good as the others ; rather short.
10	Pedigree Karunganni . . .	300		Nice style, good silky staple.
11	Do. do. . . .	295		Nice style, good staple.
12	Selected Karunganni . . .	280		Short staple.

The export valuations are rather nominal owing to the large supplies of Americans this year at reasonable rates

compared with Indian cotton. The demand from Europe is for lower priced cotton with fair staple.

	Rs.
Basis.—Fine M. G. Broach	290
Fine M. G. Naosari	330
Fine G. F. Tinnevelly	310
Fine M. G. Bengal (Rajputana)	265
Fine M. G. Akola	275

Valuation of 8 samples of cotton from Bellary (Madras), furnished by the Bombay Chamber of Commerce, on the 31st May 1912.

Serial No. (according to merit).	Historical Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount on 29th May 1912.	Remarks.
		Rs.	
1	Kappas and Lint of No. 3. Grown at Bellary Farm this year. This is a selection made in 1906-07 from a sample of Broach seed obtained from Surat.	295	Strict fine in class too yellow in colour for Broach description, staple about equal to Broach and quite as silky. Colour of the kappas is white but the cotton has a yellow tinge.
2	Kappas and Lint of No. 41. These are single plant-selections from the local cotton made in 1908-09. Grown at Bellary Farm.	288	Better in staple than No. 21.
3	Kappas and Lint of No. 21. Grown at Hagari Farm. This is an inter-cross of the local cotton.	285	Class as good as No. 11 ; staple a good deal better.
4	Kappas and Lint of No. 5. Grown at Bellary Farm this year. This is a selection made in 1906-07 from Kumpta-seed.	280	Has not got the usual Kumpta characteristics, class strict fine, fair to good staple.
5	Kappas and Lint of No. 11. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	278	Class rather lower than No. 10, but staple better.
6	Kappas and Lint of No. 10. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	275	Brighter and whiter than No. 9, staple also better but irregular.
7	Kappas and Lint of No. 44. Single plant, selection made in 1908-09 from the local cotton. Grown at Bellary Farm.	275	Class strict fine, but staple not so good as Nos. 11, 21 and 41.
8	Kappas and Lint of No. 9. Grown on Bellary Farm. This is an inter-cross of the local cotton. The selection was made in 1906-07.	265	Disappointing in staple and decidedly inferior in style to the ordinary Westerns and has not the same bulk, but class much better.

	Rs.
Basis.—Tinnevelly	295
Fine M. G. Broach	280
Good M. G. Kumptas	285
„ „ Westerns	270

Mysore.—In the Mysore State preliminary steps have been taken to establish the cultivation of higher class cotton in non-cotton growing areas and we expect that valauble assistance will be renderd in this direction by the co-operation of the European planters.

North-West Frontier Province.—In consultation with Mr. Robertson Brown it has been arranged that he is to grow large plots of his cottons and that I shall visit his farm when the crops are ripe, to arrange, on the spot, the line of future work he should take in hand.

He gave the following information in a letter to the Inspector General of Agriculture (now the Agricultural Adviser to the Government of India) : "I have just visited a tract in the Peshawar District which is famous in the North-West Frontier Province as producing heavy crops of high class cotton. I was accompanied by the Revenue Assistant, who fixes revenue, etc., so my information is correct. I found that the *banias* in purchasing the crops pay for 6 maunds and take their chances of profit on the outturn beyond that weight. Good average cotton fields in the tract yield 16 maunds per acre and 20 maunds is occasionally produced. I have not seen such heavy outturns of cotton recorded as being produced elsewhere in India, and I am writing to you to find if equally good crops are yielded in any other part. The soil is deep red alluvium and the tract irrigated very sparingly and irregularly from the rich, muddy, Bara River."

Lalio cotton, in the Bawla Taluka, in the Ahmedabad District, under two or three waterings in light soils, is said to yield as high as 1,600 lbs. *kapas* per acre, but the high returns quoted by Mr. Robertson Brown, so far as I know, must be unequalled elsewhere in India.

The following report on a sample of Mr. Robertson Brown's cotton has been received from Messrs. Tata, Sons & Co. :—

> "In all its characteristics it is Oomra style of cotton. Comparing it with Fine Akola ginned at Rs. 275 we value the sample at Rs. 270 as it

is slightly shorter in fibre. We quote Sind Punjab cotton to-day at Rs. 270. Though the sample is from the North-West Frontier Province it cannot be compared with Sind Punjab as the latter is whiter in colour but short in staple and coarse to the feel. The sample examined is of a dull white colour like Akola, the staple is longer than that of Sind Punjab and has better feel."

Experiments with Bhuri cotton on the Khetri Estate in Rajputana.—The seed was given by me for experiment to the Munsarim of this estate who has been courteous enough to furnish a report of his results. I may mention that such thoughtfulness is rare amongst my numerous correspondents. Two and half seers of seed were sown in an acre of land, the plants were spaced $1\frac{1}{2}$ foot apart and the land was watered four times before the rains and twice after the rains. The area consisted of garden land of the first class and the cotton finally collected weighed $2\frac{3}{4}$ maunds.

Messrs. Tata, Sons & Co. kindly furnished the following valuation on a sample of the cotton submitted to them :—

"*Bhuri.*—This cotton has vastly improved and is better than the best cotton grown in India, *viz.*, Naosari. The fibre is very long and is stronger than that of Naosari cotton. On the basis of Naosari at Rs. 335 we value it at Rs. 350 or fully Rs. 15 more per candy."

Arrangements are being made for a more extended trial with *bhuri* in the same locality during the present season. Rajputana appears to offer strong inducements for the production of higher class cottons, but it is difficult to get into touch with its people. I have reason to believe, however, that there is a spontaneous introduction of *bhuri* cotton into the States from Berar.

Bombay.—The following are some of the definite conclusions which have been arrived at in this Presidency :-

At Surat it has been decided to make a reduction in the number of varieties so as to simplify the work, and to discontinue the cultivation of tree cottons as not one has given a useful result.

At the Ganeshkhind Botanical Garden it has been proved that Bourbon only lasts for 6 years which is far short of the 20 years of life claimed for it.

At Dhulia it has been found that the white-flowered *Varhadi* excels in yield and ginning percentage. It has produced 1,500 lbs. of seed cotton per acre, of a value of over Rs. 200. Comparing price and outturn it easily outstrips in value all other Khandesh or Berar cottons. *Karkeli*, although of very high quality, does not yield sufficiently well to be remunerative.

At Dharwar, Cambodia cotton has not continued to be immune from red leaf blight. Mr. Main has arrived at the following conclusions regarding it :—

(1) Cambodia cotton can be grown most profitably in the early part of July in spite of the liability of early sown cottons to red leaf blight.

(2) The early sown crop begins to flower about the middle of November, but these flowers drop off and bolls do not set till December-January.

Bhuri again did badly. It suffered from the red leaf blight believed to be the disease known as the Mosaic in the United States of America. It appears to be less suitable than Cambodia for the conditions obtaining at Dharwar.

At the Gadag Farm, Cambodia Cotton has been proved to be the most suitable substitute for Dharwar American cotton in the eastern part of the Dharwar District, as it surpasses it in yield and ginning percentage.

The trials with numerous American cottons show that they all require considerable acclimatization. Mr. Main also finds that the green fuzz of the seeds of certain Dharwar American plants is not a fixed character as a number of white fuzz seeded plants are produced from green fuzzed

seed. On the other hand, white fuzzed seed appears to be a fixed character and such seed breeds true. These facts lead him to suppose that the colour of the fuzz may be a character which conforms to Mendelian laws. Experiments are still being persevered with towards the introduction of cotton into areas of land, lying waste partly owing to the damage liable to be caused by wild pigs. It is observed that cotton is not touched by these animals.

It is gratifying that the demand for Naosari and Cambodia cotton seeds is steadily increasing in the Karnatic. During the year under report both these cottons maintained higher ginning percentages and at the auction sale realized as in previous years more encouraging prices than the local Kumpta and Dharwar American as shown in the statement below :—

Variety.	Ginning percentage.	Value per naga of 1,344 lbs.
Broach (from Naosari seed) .	33	Between Rs. 170 and Rs. 203 according to grades.
Kumpta	27	Rs. 140.
Cambodia	37	Between Rs. 188 and Rs. 206 according to grades.
Dharwar American . .	30	Between Rs. 140 and Rs. 145.

At Mirpurkhas in Sind, the highest yield of Sindhi cotton was 1,304 lbs. per acre, the second best was at the rate of 960 lbs. per acre. This is compared with 1,683 lbs. seed cotton obtained in the previous year and with 1,280 lbs. in 1907. The best results have always been obtained from April sowings of cotton.

Some valuations by Messrs. Tata, Sons & Co. of cottons grown on the Agricultural College Farm, Poona, are interesting as they demonstrate two points : first, the influence of an unsuitable environment on cottons which require a better

soil and climate, and second, the ease with which the different types of "Bengals" can be separated.

No. 1. *Broach.*—From seed imported from Naosari in 1911. "This cotton grown from Naosari seed on Kirkee Farm is not exactly like Naosari cotton. It is decidedly superior to Broach and is equal to Surat cotton. Value Rs. 310 (Naosari at Rs. 330 per candy)."

No. 2. *Varhadi.*—Seed obtained from Akola in 1911. "This cotton is equal to short stapled Oomra. Value Rs. 255."

No. 3. *Bhuri.*—Seed obtained from Akola in 1911. "This cotton is superior to No. 1, and we class it as best Naosari. Value Rs. 330."

No. 4. *Cambodia.*—Seed obtained from Gadag in 1911. "This cotton is equal to best Surat. Value Rs. 320."

In Nos. 5, 6, 7 and 8, the seed was obtained from Akola five years ago and was sown just as it was. The types were separated out on the farm from this mixture and grown separately in succeeding years.

No. 5.—(Yellow flowered, broad lobed *neglectum*, from Dhulia mixture.)—"Dhulia seed gives improved cotton in Kirkee soil. It has produced cotton equal to Ghat Akola, good staple. Value Rs. 285."

No. 6.—(Yellow flowered, narrow lobed, from the same mixture.)—"Slightly inferior to No. 5. Value Rs. 280."

No. 7.—(White flowered, broad lobed, from the same mixture.)—"This cotton equals the lowest grade Khandesh and is very poor in staple. Value Rs. 245."

No. 8.—(White flowered, narrow lobed, from the same mixture.)—"This cotton equals ordinary Khandesh, and is very poor in staple. Value Rs. 255."

Basis of valuation on 10th July 1912 :—

	Rs.	
Naosari	330	per candy.
Surat	310	„
Broach	290	„
Akola	275	„
Khandesh	265	„

Judging from the valuations received from Messrs. Tata, Sons & Co., the Kumpta cotton from the Sangli State in the Southern Mahratta Country fetches a higher price than that of the same country to the southward. There are presumably highly favourable conditions of soil and climate in this State and the Department of Agriculture, Bombay, may see its way to investigate the possibilities of this tract as a seed distributing centre of Kumpta cotton.

The suspicions of Messrs. Tata, Sons, that the labelling of the bags was transposed, is not confirmed.

The Agricultural Superintendent of the State had grown Broach from seed imported from Naosari and the Kumpta was from an *inter se* cross.

The following are Messrs. Tata's valuations and remarks (on 11th March 1912) :—

"*Sample No. 1.*—Broach cotton grown at Sangli from the seeds imported from Naosari. The cotton shows much improvement, both in colour and staple. Though a slight tinge of red can be detected, the colour is more than fine. On the basis of Rs. 330 for Naosari cotton, we value this at Rs. 340 per candy.

"*Sample No. 2.*—Local (Kumpta) cotton crossed *inter se*. This is really a beautiful cotton, soft and silky in feel with a strong and even fibre, equal to, if not better than, Naosari cotton in length. It is more like indigenous Naosari cotton than like Kumpta. In fact we were in doubt whether a mistake had not been made in bagging the samples. It is really better than No. 1 in all respects and we value it at Rs. 20 over No. 1, *viz.*, Rs. 360 per candy.

> " The Sangli soil appears to be eminently suited to the growth of Kumpta cotton, crossed *inter se*, and it is worth experimenting with on a large scale."

The Native States of Palitana and Rajkot in Kathiawar have been supplied with cotton seeds of varieties at their request and the results will be watched with interest.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation; and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

A few samples were also submitted to the Bombay Chamber of Commerce to whom thanks are also due.

Programme of work for 1912-13.

It is proposed to tour in the North-West Frontier Province in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. Tours will also be made in the Bombay Presidency and the Central Provinces and to other parts also, if my services are called for to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done.

In addition I shall continue my special researches in the botany and cultivation of cotton.

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